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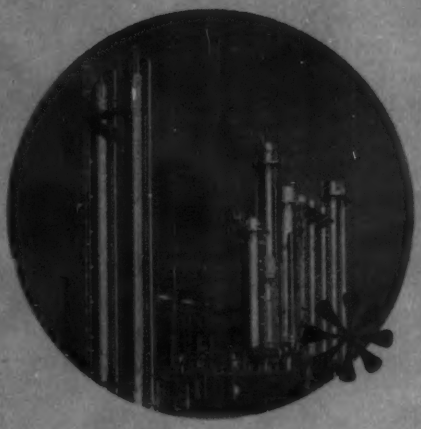
Petroleum Refiner

FEBRUARY
1958

Special Report on Perforated Trays 103



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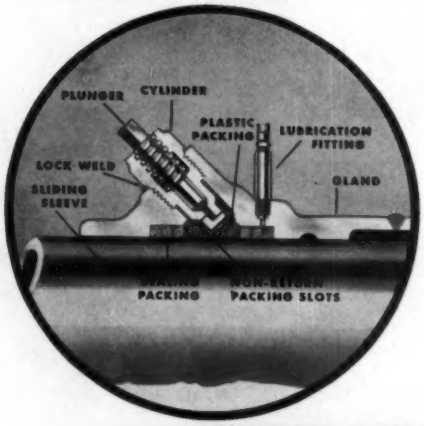
Cross-section of Gun-Pakt feature. To add packing, just add a plug and turn the plunger. Note non-return packing slots at bottom of cylinder.



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Volume 37, No. 2 February, 1958

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Petroleum Refiner

REFINING • PETROCHEMICALS • NATURAL GASOLINE

A Quick Look

at This Issue

These handy digests permit checking ☑ the articles you want to read first.

☐ **Perforated Trays Designed This Way . . .** This report pulls together the most reliable information available for the design of perforated trays. For suggestions on handy work sheets to carry out actual design calculations, turn to Page 103.

☐ **In California: Petrochemical Boom? . . .** Here's an historical review of California in the over-all petrochemical industry. Actually starting in 1931 with synthetic ammonia production, the industry has experienced some retrenching since World War II. This is background information for your planning file. Turn to Page 119.

☐ **Applied Hydrocarbon Thermodynamics (Part 2) . . .** This part will bring you up to date on equations-of-state, compressibility factor methods, mixture charts, etc. You'll want to refresh your memory with this information so that you'll be ready for the newer material starting in Part 3 next month. See Page 123.

☐ **How to Design Static Adsorption Beds . . .** Here are the equations for factors involved in the design of static adsorption beds. These beds may be used to decolorize, purify, or finish a range of petroleum stocks. Check this article before you start on your next adsorption bed design problem. Page 131.

☐ **Charts Make Cat Cracker Balance Easier . . .** Here is a close look at the variables involved in a fluid catlytic cracking unit. You can use the charts to test unit data or to examine the factor affecting regeneration temperature. Page 135.

☐ **Equilibrium Data Now Available for Cyclohexane . . .** Here is a practical method for calculating the vapor equilibrium constants for pure components. Data for cyclohexane are presented to

Please Turn Page ➔

show you how the method works. The next time you are unable to find equilibrium data, calculate your own. Turn to **Page 143.**

☐ **Reinforced Opening Design Simplified . . .** Use this data sheet for fast, accurate calculations when working with nozzles in a shell or head. A composite drawing of the condition and the appropriate formulas are included. For complete details, see **Page 146.**

☐ **Analyze for Ba, Ca, and Zn This Way . . .** An extraction-titration method has been developed for the determination of barium, calcium and zinc in lube additives and oils. It is rapid enough to apply to quality control in manufacturing, and accurate enough to use as a referee. **Page 147.**

☐ **Know Your Asphalts (Part 6) . . .** Here are five more important tests for asphalt quality. These are the most controversial, and their interpretation affects asphalt selection. Another addition to your asphalt data book. Turn to **Page 150.**

☐ **Centralize Your Spare Parts Program . . .** It's impractical to have a spare part for each piece of plant equipment. But, here's a system that will tell you how to keep the minimum number of spare parts on hand to give protection in case of equipment failure. For complete details, turn to **Page 151.**

☐ **Terephthalic Acid from Xylenes . . .** Four commercial routes for oxidation of p-xylene to terephthalic acid are discussed. Process variables and their effect on yields are compared. Feed preparation can be important if a value can be assigned to o-xylene. Before you select a TPA process, see **Page 155.**

☐ **Reduce Thickness by Overstrain? . . .** By working to the highest degree of stress, achieved through overstrain, vessel wall thickness can be reduced. Here is a method for calculating the most advantageous degree of overstrain. Add this to your vessel design notebook. Turn to **Page 163.**

☐ **The Elusive Art of Thinking . . .** There is growing concern that too many industry executives are reluctant to think. Here are the reasons why, plus some think "stimulators" guaranteed to stretch your brainpower to the limit. Test your thinking ability on **Page 199.**

☐ **How to be a Man of Letters . . .** Business letters reflect on both the engineer and the refinery. Even though this is generally known, too many engineers are still writing letters that include words and phrases of 1890 vintage. Actually, it is easy to write a letter that is a credit to you and your company—just follow the five simple rules outlined on **Page 202.**

☐ **Do You Use Work Simplification? . . .** Here is a time and money-saving program tailor-made to help supervisors eliminate bottlenecks, low output, backlogs, overtime and low morale. Be sure to check this work simplification plan—you may decide to use it in your refinery. Turn to **Page 206.**

☐ **How to Determine Training Needs . . .** Supervisors have no problem finding good refinery training projects. The potential is almost unlimited. However, there is one big problem—to determine the type of training that is needed most. And even that problem can be a small one if you follow the excellent plan explained in detail on **Page 211.**

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We Get Some Help

THESE ARE THE INDUSTRY MEN who sat with PETROLEUM REFINER editors during their annual editorial conference held last December in Rocksprings, Texas. Here PR's past, present and future editorial content was carefully evaluated and plans laid for reading content that parallels reader interests and needs.

These conference have been a part of PR's editorial planning for many years. In addition to the annual "brain picking," industry guests are invited to such group meetings throughout the year when special issues or special reports are considered in detail.

The group pictured above, l to r, shows Howard Halff, Houston, of The Texas Company's gas engineering group; J. D. Wall, assistant mechanical superintendent, Magnolia Petroleum Co., Beaumont; James A. Goolsbee, process engineer, Tellepsen Petro-Chem Constructors, Houston; J. F. Horner, assistant director, Research and Development, American Oil Co., Texas City; and A. E. New, technical director, Escambia Chemical Corp., Pensacola, Fla.

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We still have a stack of PR's highly regarded Petrochemical Handbook which appeared in the November issue. And in their case, too, they won't be available forever; so we suggest your order (at $1. per copy) be started Houstonward right off. Use same address as above.

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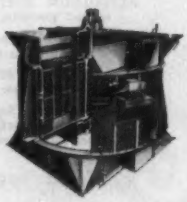

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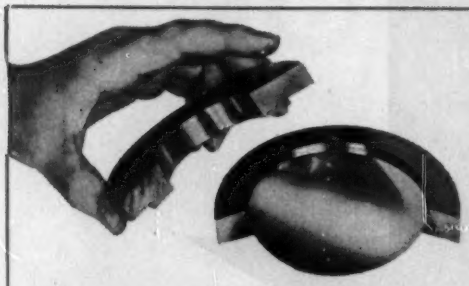

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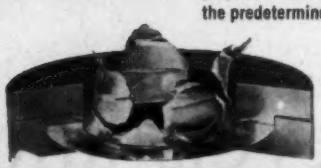

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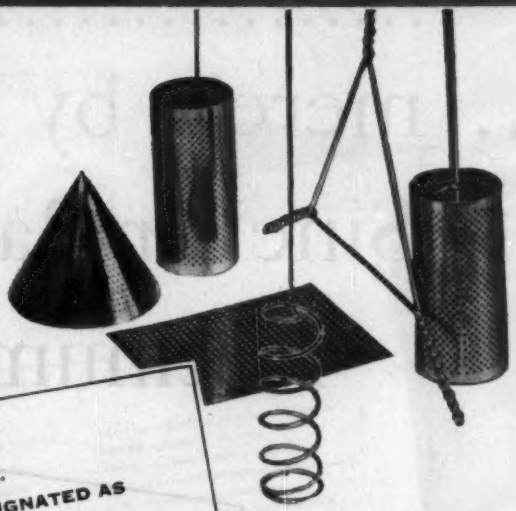

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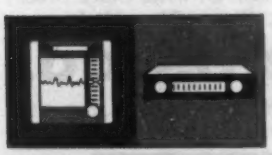

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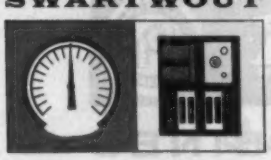

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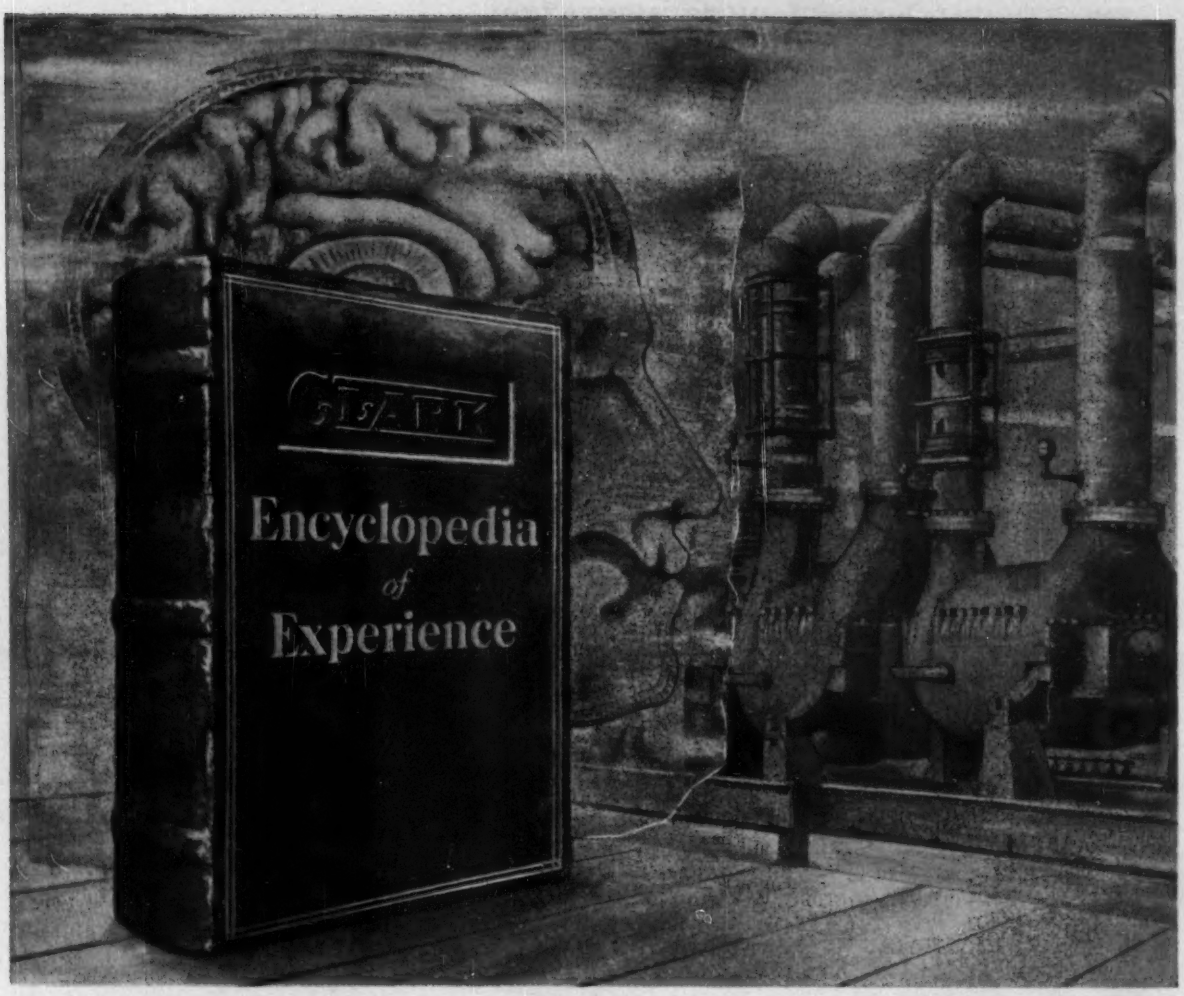

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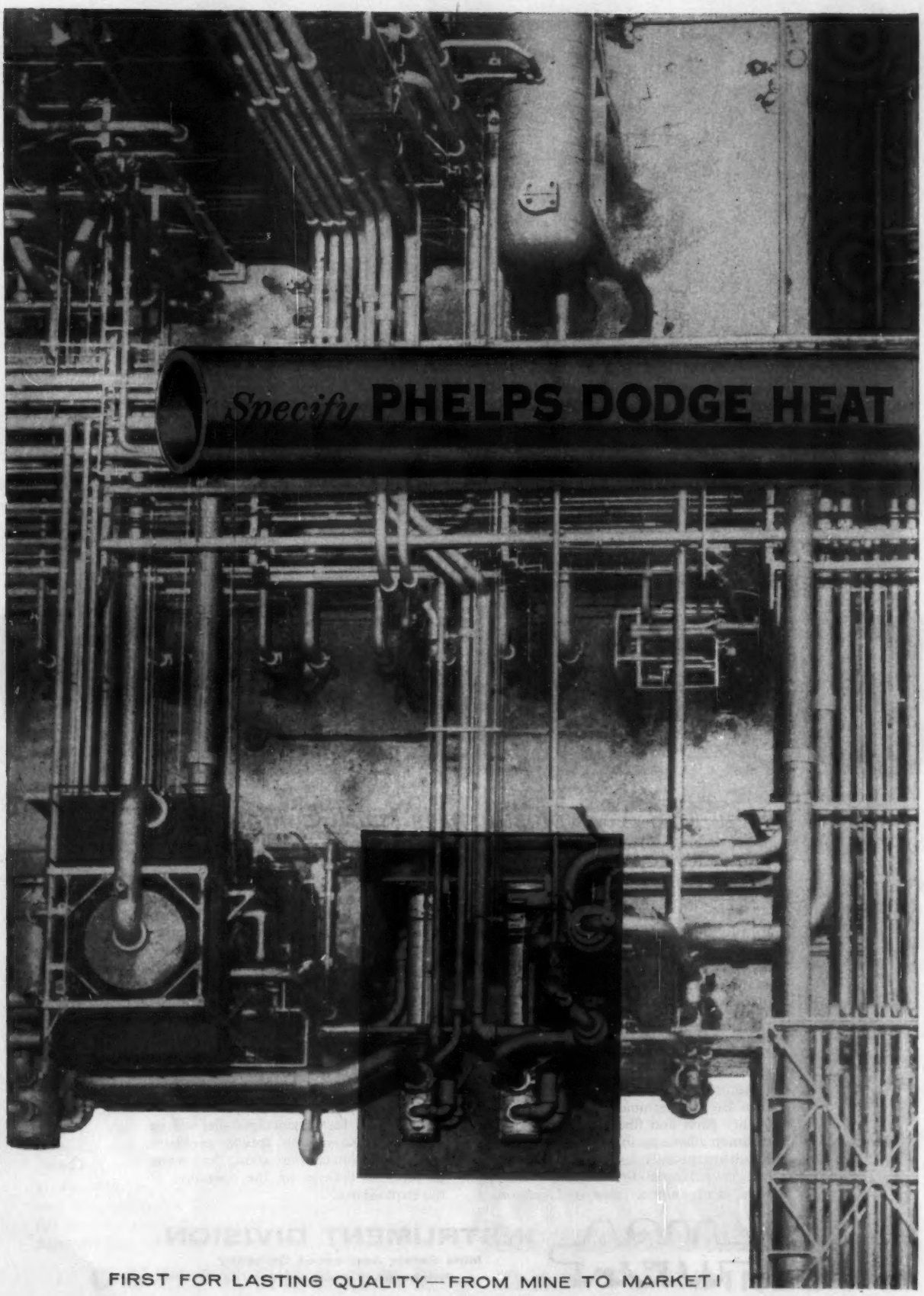

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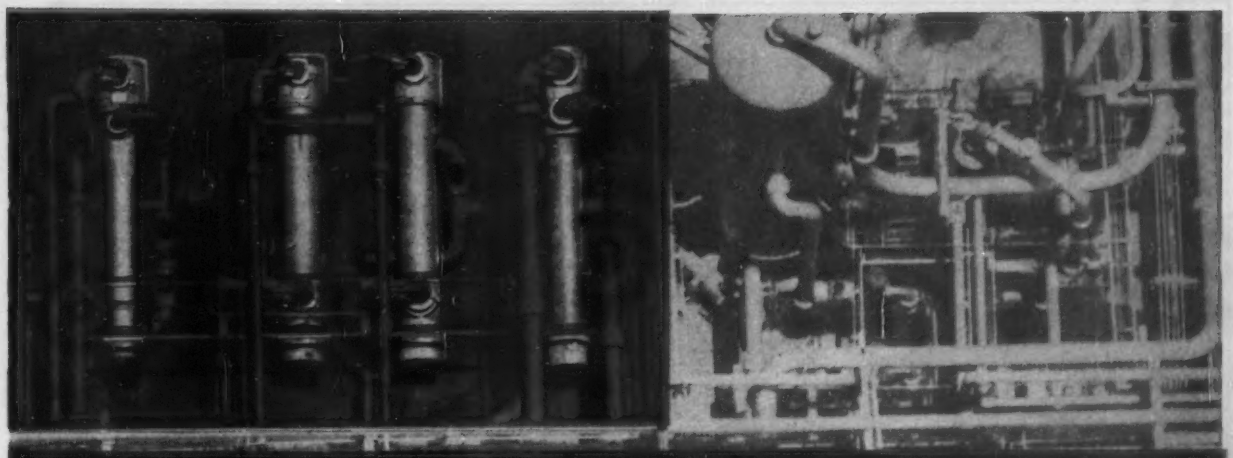
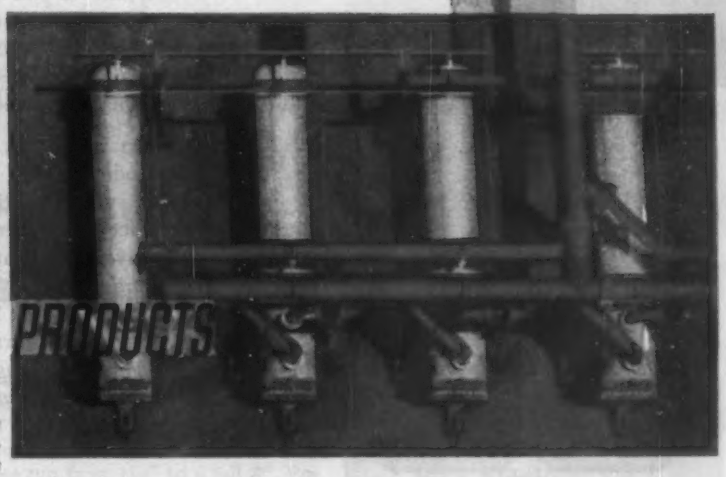


EXCHANGER TUBES *for Longer Service!*

- Full range of copper-base alloys for every application.
- Vast background of application engineering to assist in proper alloy selection.
- Complete control of quality throughout every step of manufacture.



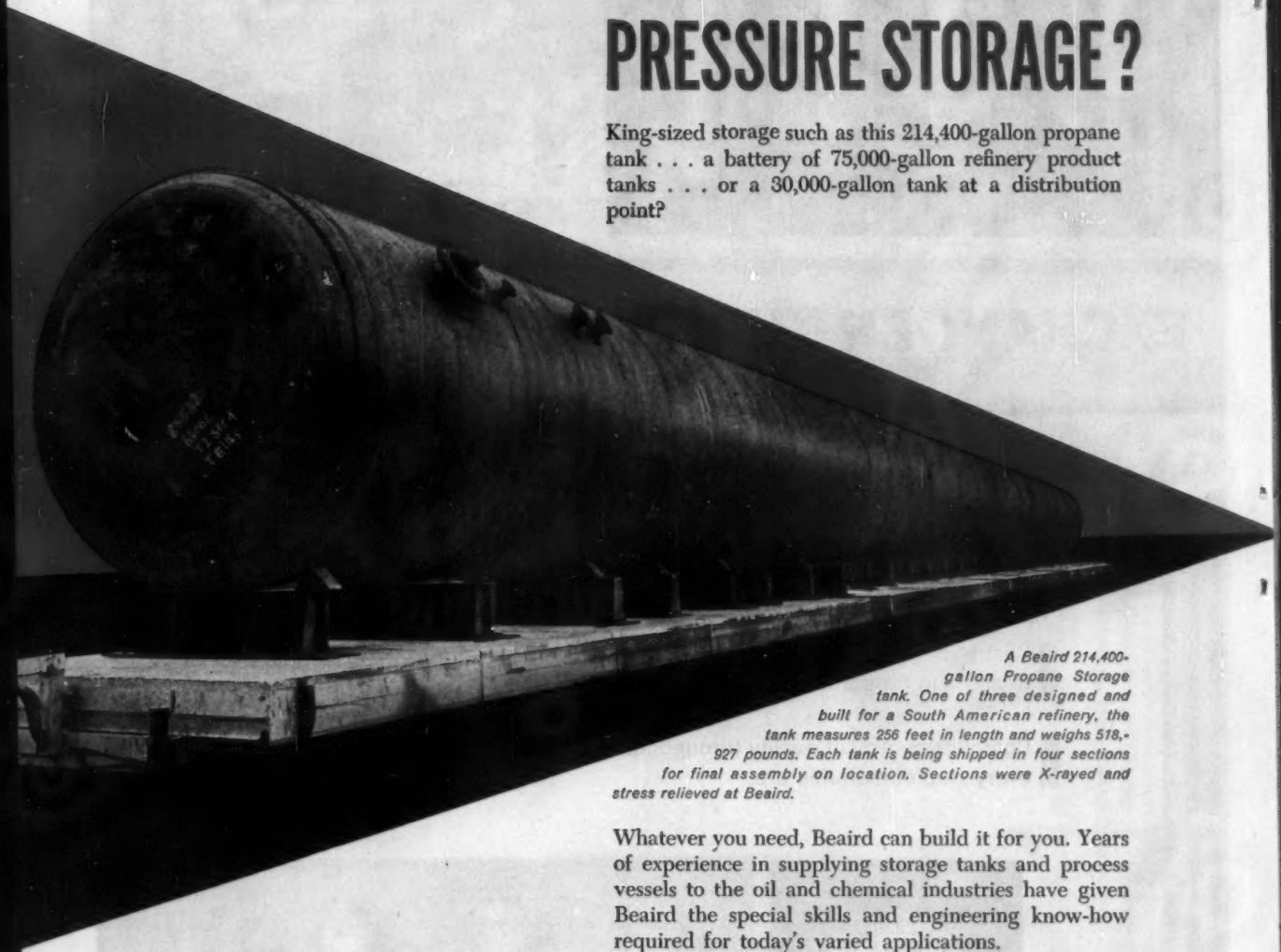
PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Cambridge, Mass., Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

For more data on advertised products, use Readers' Service Cards, last page.

What do YOU need in PRESSURE STORAGE?

King-sized storage such as this 214,400-gallon propane tank . . . a battery of 75,000-gallon refinery product tanks . . . or a 30,000-gallon tank at a distribution point?



A Beaird 214,400-gallon Propane Storage tank. One of three designed and built for a South American refinery, the tank measures 256 feet in length and weighs 518,-927 pounds. Each tank is being shipped in four sections for final assembly on location. Sections were X-rayed and stress relieved at Beaird.

Whatever you need, Beaird can build it for you. Years of experience in supplying storage tanks and process vessels to the oil and chemical industries have given Beaird the special skills and engineering know-how required for today's varied applications.

You benefit as well from Beaird's Quality Control. Modern X-ray equipment, hydrostatic testing, stress relieving facilities, full-time insurance inspectors and strict adherence to fabricating code procedures all play important roles in building Beaird pressure storage.

When your next project is in the idea stage, call in a Beaird sales engineer. His specialized knowledge can help you obtain maximum storage at lowest possible cost.

Over 200,000,000 Gallons Experience

BEAIRD
another AMF product
PRESSURE STORAGE VESSELS

THE J. B. BEAIRD COMPANY, INC.
A Subsidiary of American Machine & Foundry
Shreveport, La. • Stockton, Calif. • Clinton, Iowa

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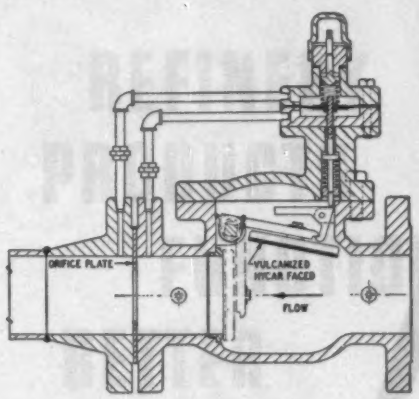
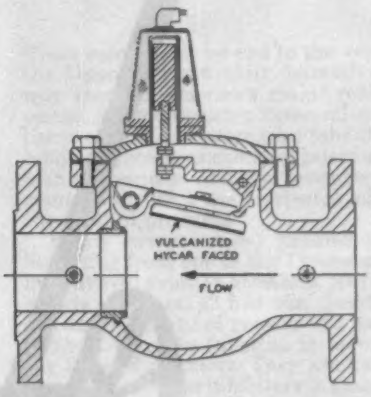
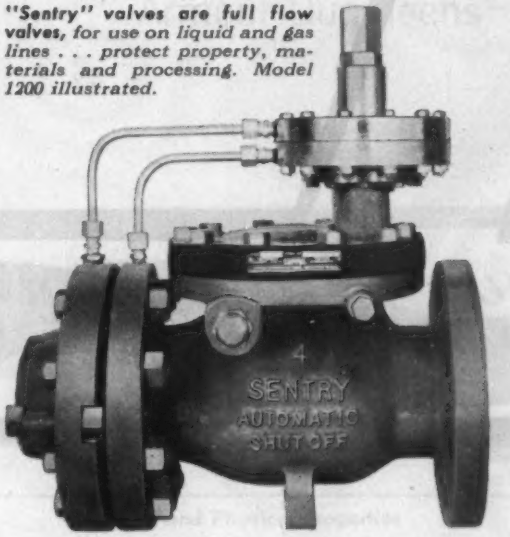


Model 1200. "Sentry" **excess flow valve** *automatically and instantaneously shuts off when the rate of flow in the line exceeds a predetermined rate.*

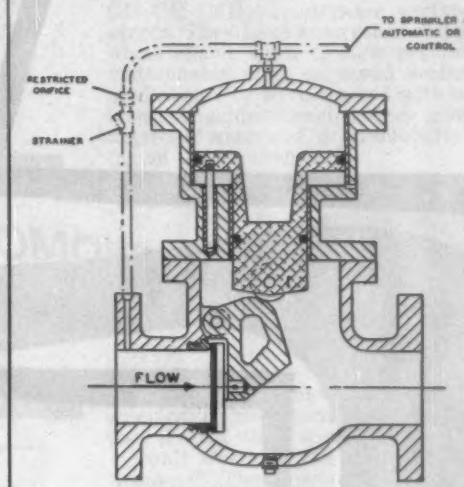


Models 1700 and 1800 "Sentry" **solenoid shut-off valves** *operate by remote electrical control automatically and instantaneously. In Model 1700, solenoid is energized, in Model 1800 solenoid is de-energized to maintain flow.*

"Sentry" valves are full flow valves, *for use on liquid and gas lines . . . protect property, materials and processing. Model 1200 illustrated.*



Other types "Sentry" Valves: high-pressure and low-pressure and over temperature shut-off valves available.



Model 3000 "Sentry" **piston operated quick-opening valve** *opens instantaneously when the pressure above piston is released. Ideal for deluge systems — and for remote opening and closing of fuel line.*

Now Coppus brings you "Sentry"® Valves for automatic protection

These valves are *patented* quick-closing latch type and quick-opening piston type. All are full flow valves.

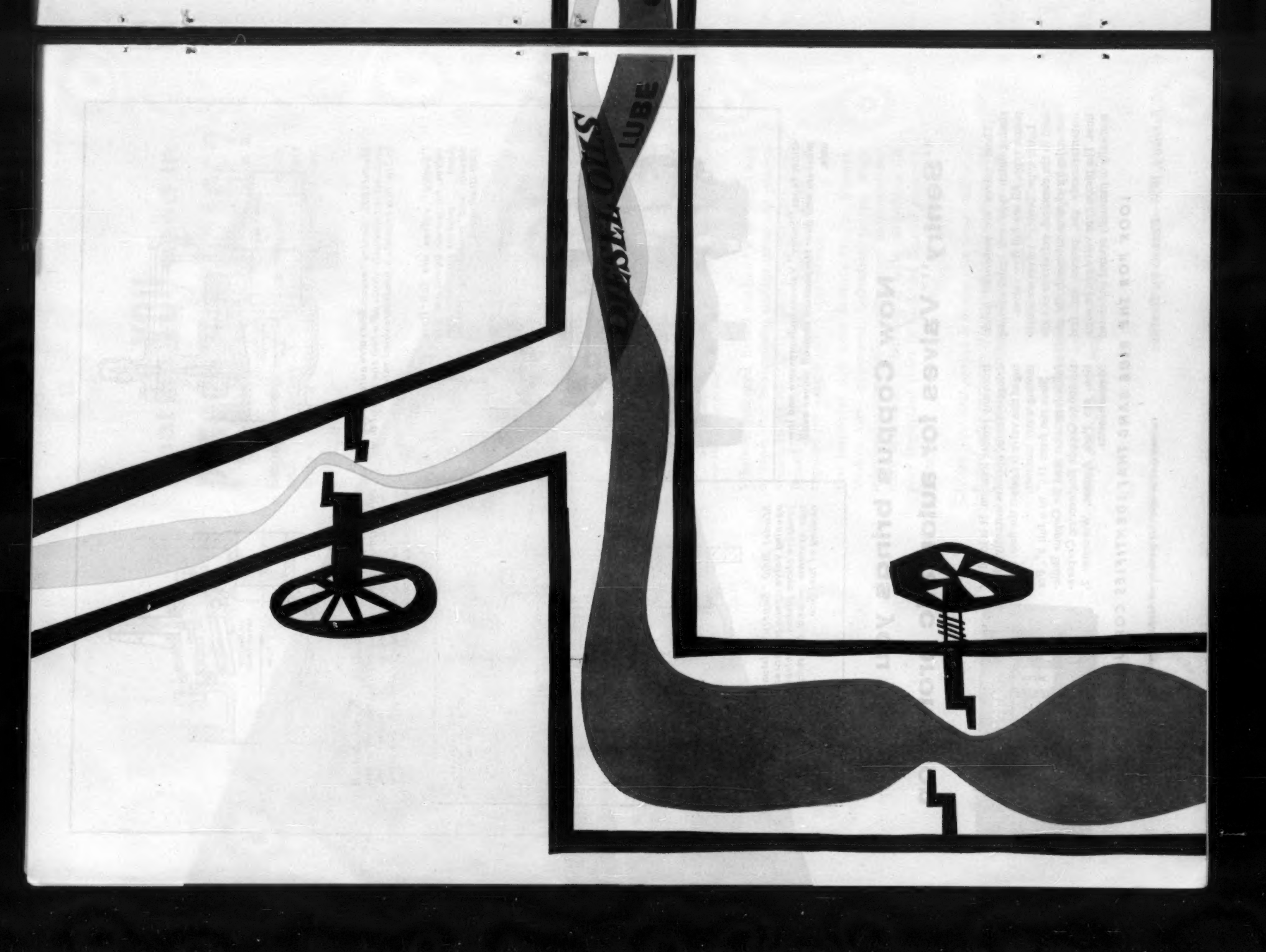
Latch-type "Sentry" valves are widely used in the chemical, petroleum and gas industries for closing automatically and instantaneously gas, process and fuel lines. The piston type valve can be automatically or manually opened and closed from any remote location. It is ideal for deluge systems, operates instantly; closing of this valve is against the flow, eliminating water hammer.

Sizes run from 1½" to a full 8". For full information send for Coppus Bulletin 500 to Coppus Engineering Corporation, 415 Park Avenue, Worcester 2, Massachusetts.

ANOTHER
COPPUS
"BLUE RIBBON" PRODUCT

LOOK FOR THE BLUE BAND THAT IDENTIFIES COPPUS QUALITY

For more data on advertised products, use Readers' Service Cards, last page.


LUBE

REFINERY PRODUCTS FUNCTION BETTER

when you add versatile
Armour Duomeens®

There seems to be no end to the versatility of the Duomeens and their derivatives. That's why most of America's major refining companies are today using these oil-soluble, cationic chemicals as corrosion inhibitors in the refining process, as chemical intermediates for making various refinery products—and, of course, for direct use as special additives in the finished products.

Nearly every refinery finished product is benefiting from one of the Duomeens or their derivatives: aviation gasolines, jet fuels, automobile gasolines, #2 fuel oils, diesel oils, lube oils and a variety of greases—to name a few.

The Duomeens function in many ways in the finished products. They are used as outstanding corrosion inhibitors in gasolines, lube oils and greases. They have few equals when used as sludge inhibitors in various fuels and oils. Then too, many oil companies are putting Duomeens into hi-pressure oils and greases where they act as pressure lubricants and oiliness agents. The Duomeens also function as de-icers in gasolines.

The Duomeens are dipolar . . . $R(NH)CH_2CH_2CH_2(NH_2)$ . . . organic surface active agents. They have adsorption characteristics which enable them to form organophilic or hydrophobic films on metal surfaces when used alone—or when reacted with organic or inorganic acids. Reacted, they give varying degrees of water and/or oil solubility, depending on the requirement.

Chemical and Physical Properties

	Duomeen C		Duomeen T		Duomeen S	
	Min.	Max.	Min.	Max.	Min.	Max.
Iodine Value	5	15	32	50	50	
% Active Duomeen	83		83		83	
Primary Amine	35	45	35	45	35	45
Secondary Amine	38		38		38	
Moisture %		1		1		1
Color—FAC		19		19		13
Melting Point 25°C	20	24	38	43	33	38
Combining Weight	304	311	377	386	378	387
Appearance @ 25°C	Liquid		Soft Paste		Heavy Liquid	
Specific Gravity @ 25°C	0.836		0.841		0.846	
Viscosity @ 25°C	10 cps.		880 cps.		70 cps.	
Viscosity @ 30°C	—		70 cps.		40 cps.	
Viscosity @ 35°C	—		10 cps.		10 cps.	

These chemicals have passed industry-wide specification tests such as the steam turbine test, the salt water spray test and others.

Don't overlook the adaptability of the Armeens®. These monopolar . . . $R(NH_2)$ . . . high molecular weight aliphatic amines have many of the same properties that make the Duomeens so popular with refineries.

Armour pioneered the use of fatty amines and diamines in refinery applications. The technical knowledge gained through many years' research and development is now available to you. Our trained staff will help you utilize the right additive for your products, or for your special situation. There is a Duomeen or Armeen—or perhaps one of their derivatives—specifically designed to solve your problem.

ARMOUR CHEMICAL DIVISION

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Leader in Progressive Fatty Acid Chemistry

SEND FOR PRODUCT SAMPLES, INFORMATION AND FREE "SLIDE RULE" CALCULATOR

☐ Duomeen Booklet PR-2

Samples of _____
(fill in chemical desired)

Application information on _____

☐ Chemical additive "Slide Rule" Calculator

Name _____

Title _____

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City _____

(Offer limited to North American Continent)

Armour Chemical Division • 1355 W. 31st St. • Chicago 9, Ill.

POWELL

world's largest family of valves

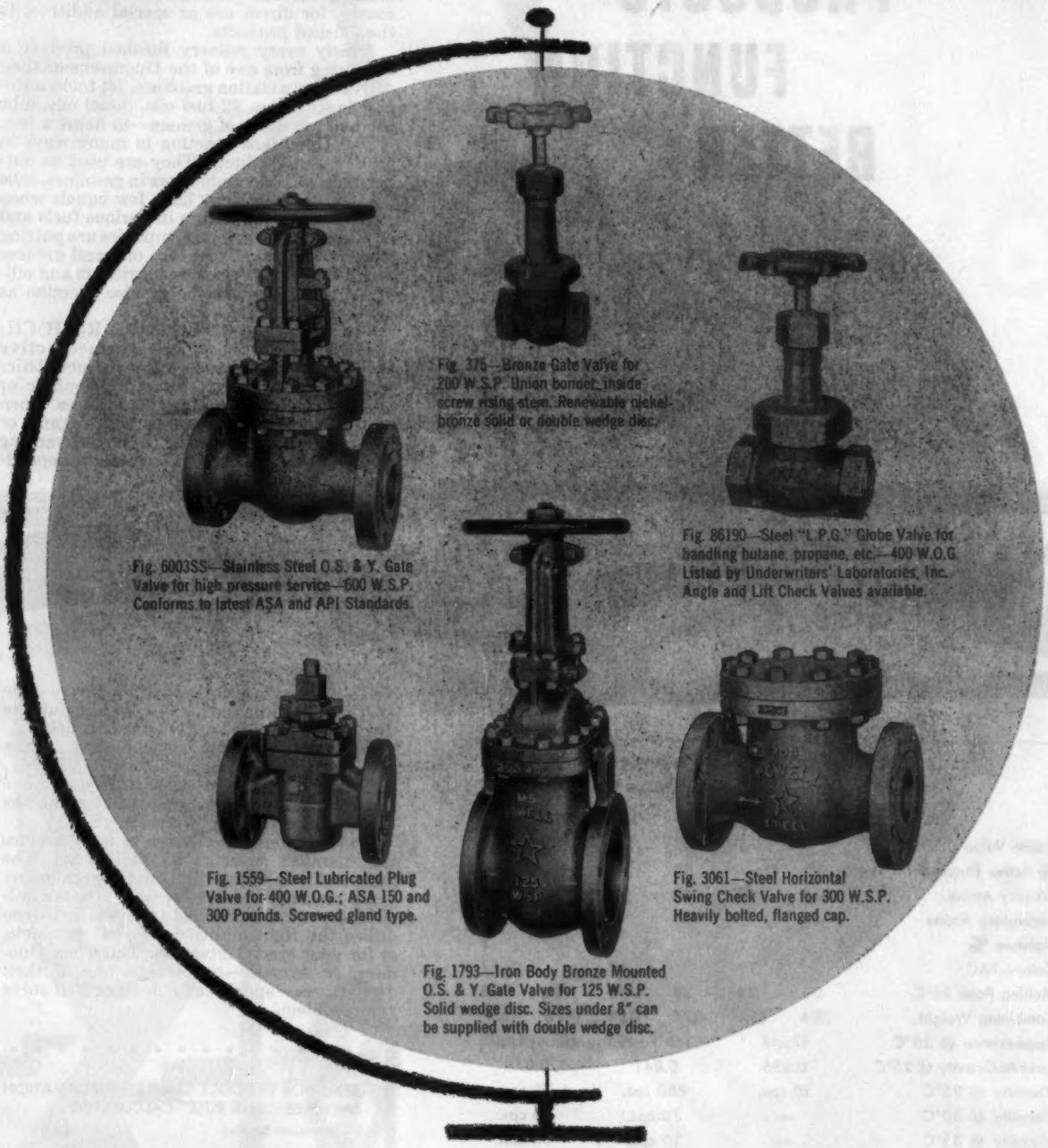


Fig. 378—Bronze Gate Valve for 200 W.S.P. Union bonnet, inside screw rising stem. Renewable nickel-bronze solid or double wedge disc.

Fig. 6003SS—Stainless Steel O.S. & Y. Gate Valve for high pressure service—600 W.S.P. Conforms to latest ASA and API Standards.

Fig. 86190—Steel "L.P.G." Globe Valve for handling butane, propane, etc.—400 W.O.G. Listed by Underwriters' Laboratories, Inc. Angle and Lift Check Valves available.

Fig. 1559—Steel Lubricated Plug Valve for 400 W.O.G.; ASA 150 and 300 Pounds. Screwed gland type.

Fig. 3061—Steel Horizontal Swing Check Valve for 300 W.S.P. Heavily bolted, flanged cap.

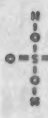
Fig. 1793—Iron Body Bronze Mounted O.S. & Y. Gate Valve for 125 W.S.P. Solid wedge disc. Sizes under 8" can be supplied with double wedge disc.

FOR EVERY FLOW CONTROL PROBLEM Powell offers more kinds or types of valves, available in the largest variety of metals and alloys, to handle every flow control requirement. Your local valve distributor will be glad to tell you all about them. Or write to us for the full facts.

THE WM. POWELL COMPANY • *Dependable Valves Since 1846* • **Cincinnati 22, Ohio**

What *lead does to control corrosion*

in producing and storing Phosphoric Acid



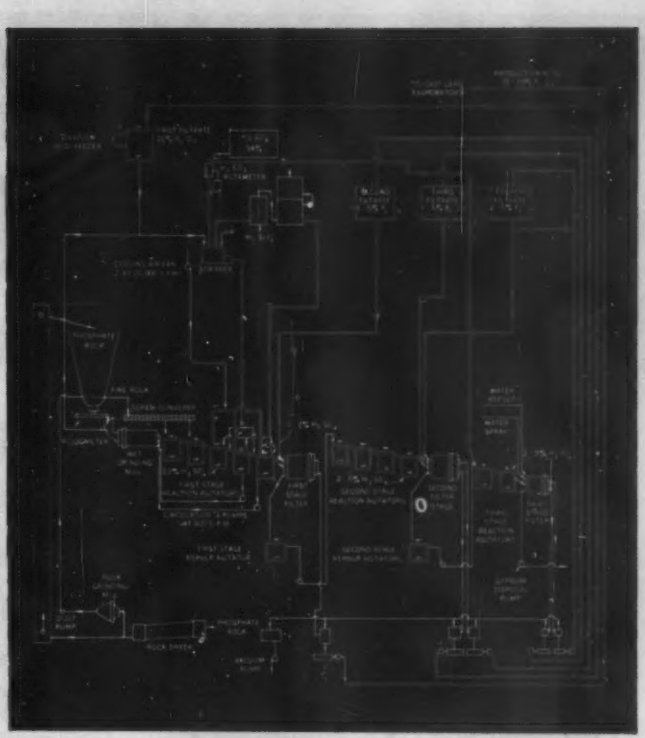
H_2SO_4 and P_2O_5 are a hungry pair.

They eat right into most metals. But *lead* takes the sharp edge off their hunger quickly.

With each of these chemicals, *lead* reacts on contact to form on the surface of the metal an insoluble and impervious film. This film stops further corrosion.

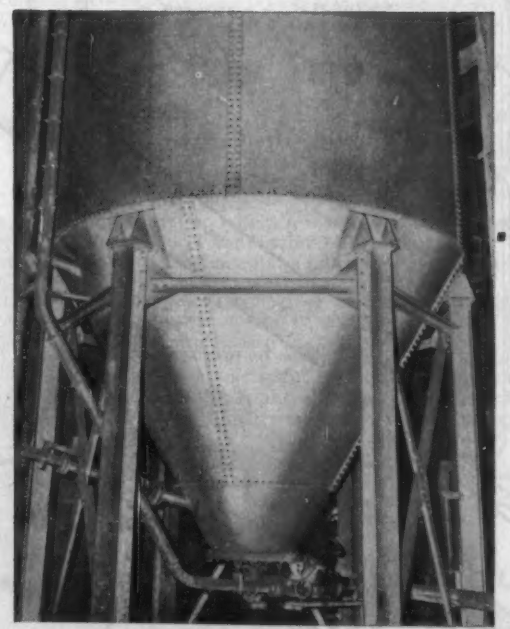
That's why *lead* has long been a "first choice" material in much of the equipment used for treating phosphate rock with sulfuric acid to produce phosphoric acid. It is used for lining vessels and tanks, in piping and pumps, in evaporator coils and for raking blades in agitators.

Recently new forms of cage-type sheet *lead* structures, new bonding and strap-lining methods, new constructions for high-temperature erosion-corrosion service and automatic stud welding techniques, have increased *lead's* usefulness . . . not only in phosphoric production but in many other applications.



What about *lead* for your own acid handling equipment . . . considered in the light of these new techniques! It's something to think about, and . . .

When you think of Lead . . .



think of National Lead Pressure Vessels

. . . lead-lined to last

Today, National Lead weds *lead* to steel . . . not only in pipe (Tubond®) and fittings (United®) but in massive and complex process and storage and shipping vessels, as well. In this equipment, the union is stronger than the tensile strength of *lead*. Bonded lead linings minimize troubles from vibration and severe and rapid cyclic temperature and pressure changes which can result in blistering, buckling and cracking. Creep is virtually eliminated.

In view of this and other developments, you may want to review your position on *lead-lined* tanks, stills, scrubbers, filters, piping, valves and other corrosion resisting equipment. If so, contact National Lead Company, Lead Lined Products, 111 Broadway, New York 6, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.

Here's Refrigeration Designed For Every Basic Oilfield Application!

...It's The New BS&B "COLD-FRAC*" Ammonia Absorption Refrigeration Unit

OUTSTANDING FEATURES:

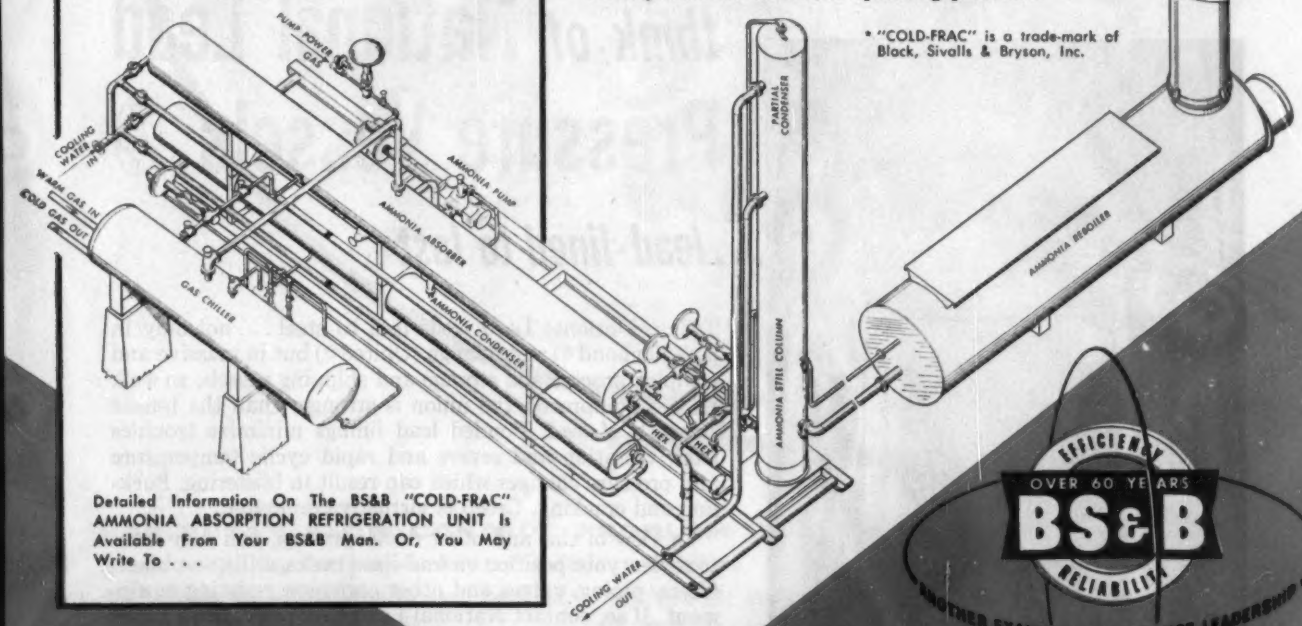
1. **Entirely Self-Operating.** Automatically Adjusts to Load Changes.
2. **Low Initial Cost.** Unit May Be Skid-Mounted Except Ammonia Reboiler. Outside Construction — No Buildings Required.
3. **Low Cost Maintenance.** Liquid Pump Is The Only Moving Part.
4. **Operating Costs Vary.** In Direct Proportion To The Load.
5. **Lower Operating Temperatures** Do Not Materially Decrease Capacity.
6. **Completely Closed System.**
7. **Chiller "Slop Over" Of Liquid Refrigerant Causes No Problem.** (There is no compressor to cause worry about liquids in the suction.)
8. **Oil Lubrication Eliminated.** No Oil-Refrigerant Problem.
9. **Vibration Free.** No High Speed Reciprocating Machinery To Mount.
10. **Experts Are Not Required** To Operate and Maintain The Unit.

With the development of BS&B's new "COLD-FRAC" AMMONIA ABSORPTION REFRIGERATION Unit, the oil industry now has a simple, non-mechanical, heavy duty artificial refrigeration system which is applicable to any oilfield or refining process requiring temperatures below ordinary atmospheric level.

A few examples of immediate industry applications are:

1. **Gas Pipeline Companies — For The Elimination Of Liquids In Gas Transmission Lines Through Better Hydrocarbon Dewpoint Control.**
2. **Gasoline Plants — For The Chilling Of Absorption Oil To Increase Hydrocarbon Recoveries Without Installing Larger Absorption Oil Towers Or Pumps.**
3. **Lease Production — To Provide Essential Refrigeration For Maximum Hydrocarbon Recovery Where Sufficient Pressure Expansion Is Not Available. Also To Supplement Declining "Natural" Refrigeration.**

These Ammonia Absorption Refrigeration Units are built for rugged, heavy duty, 365 day-per-year continuous operation, and are available in eleven standard sizes. Completely automatic in operation, they are equipped with BS&B oilfield-type controls and motor valves which are already familiar to oilfield operating personnel.



* "COLD-FRAC" is a trade-mark of Black, Sivalls & Bryson, Inc.

Detailed Information On The BS&B "COLD-FRAC" AMMONIA ABSORPTION REFRIGERATION UNIT Is Available From Your BS&B Man. Or, You May Write To . . .

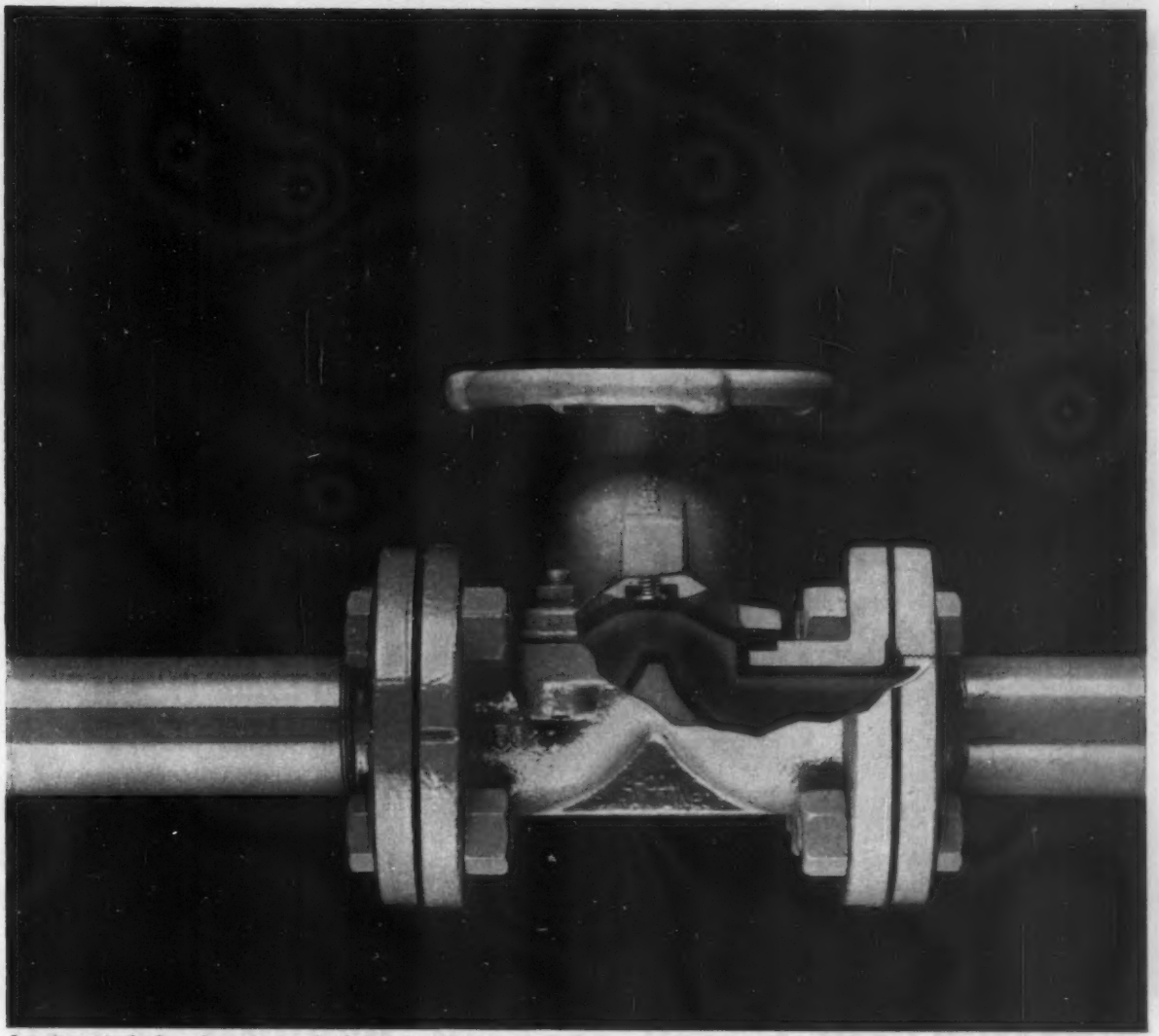
EFFICIENCY OVER 60 YEARS BS&B RELIABILITY

ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

Oilfield Equipment Division, Dept. 1-72

P. O. Box 1714 Oklahoma City, Okla.



Corrosion protection is continuous in saran lined pipe—liquid never touches metal.

Here's why Saran lined pipe offers long range economy

It's rigid steel pipe . . . lined with corrosion-resistant saran . . . keeps shutdowns to a minimum for years

Looking ahead? Do your plans call for a complete corrosion-resistant piping system with a low total installation cost . . . a system that requires a minimum of maintenance . . . that's simple to modify . . . that can be fabricated in the field?

Then it will pay you in every way to look into the genuine economy of a complete system of saran lined pipe.

First, consider the natural advantages of the new gray saran lining itself. Its lower coefficient of thermal expansion and contraction more closely approaches that of steel. This provides a broader operating temperature range and greater resistance to thermal cycling. It can be installed in systems with operating pressures from full vacuum to 300 p.s.i. and temperatures up to 200° F. Add to these advantages the immediate availability of saran lined pipe, valves, pumps and fittings and you have an ideal piping system that can be installed without trouble, waiting or hidden costs.

If your plans call for lined tanks, you'll want the advantages of Saraloy® 898 tank lining added to your saran lined pipe system. Get the complete story on how it will pay you to install a complete saran and Saraloy 898 lined system. THE DOW CHEMICAL COMPANY, Midland, Michigan.

SARAN LINED PIPE COMPANY
DEPT. 2000-F
2415 BURDETTE AVENUE
FERNDALE 20, MICHIGAN

Please send me information on:
☐ Saran lined pipe, fittings and valves.
☐ Saran lined centrifugal pumps.
☐ Saraloy 898 chemical-resistant sheeting.

Name_____ Title_____ Company_____

Address_____ City_____ State_____

YOU CAN DEPEND ON DOW

For more data on advertised products, use Readers' Service Cards, last page.

IMMEDIATE DELIVERY...

ESCO IPS SCREWED FITTINGS

CAST STAINLESS STEEL

150 LB. STANDARD

ESCO cast stainless fittings are a vital part of every corrosion resistant piping system. Cast with heavy wall sections and in a variety of analyses, *ESCO* screwed fittings are carried in warehouse stocks in sizes ranging from ⅛" to 4". Complete size range is available in 90 and 45 degree elbows, tees, crosses, unions, couplings, reducers, plugs, bushings and locknuts. Permanent alloy identification is cast in each fitting to eliminate replacement error.

Special sizes, types and alloys can be made to engineering specifications.

ESCO cast stainless fittings are available from convenient warehouse stocks. See your nearest *ESCO* dealer. He can help you solve your corrosion problems. Ask for *ESCO* Catalog No. 156 giving complete dimensional data.

ESCO

ELECTRIC STEEL FOUNDRY COMPANY

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MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.
Offices in Most Principal Cities
ESCO INTERNATIONAL, NEW YORK, N. Y.
IN CANADA ESCO LIMITED

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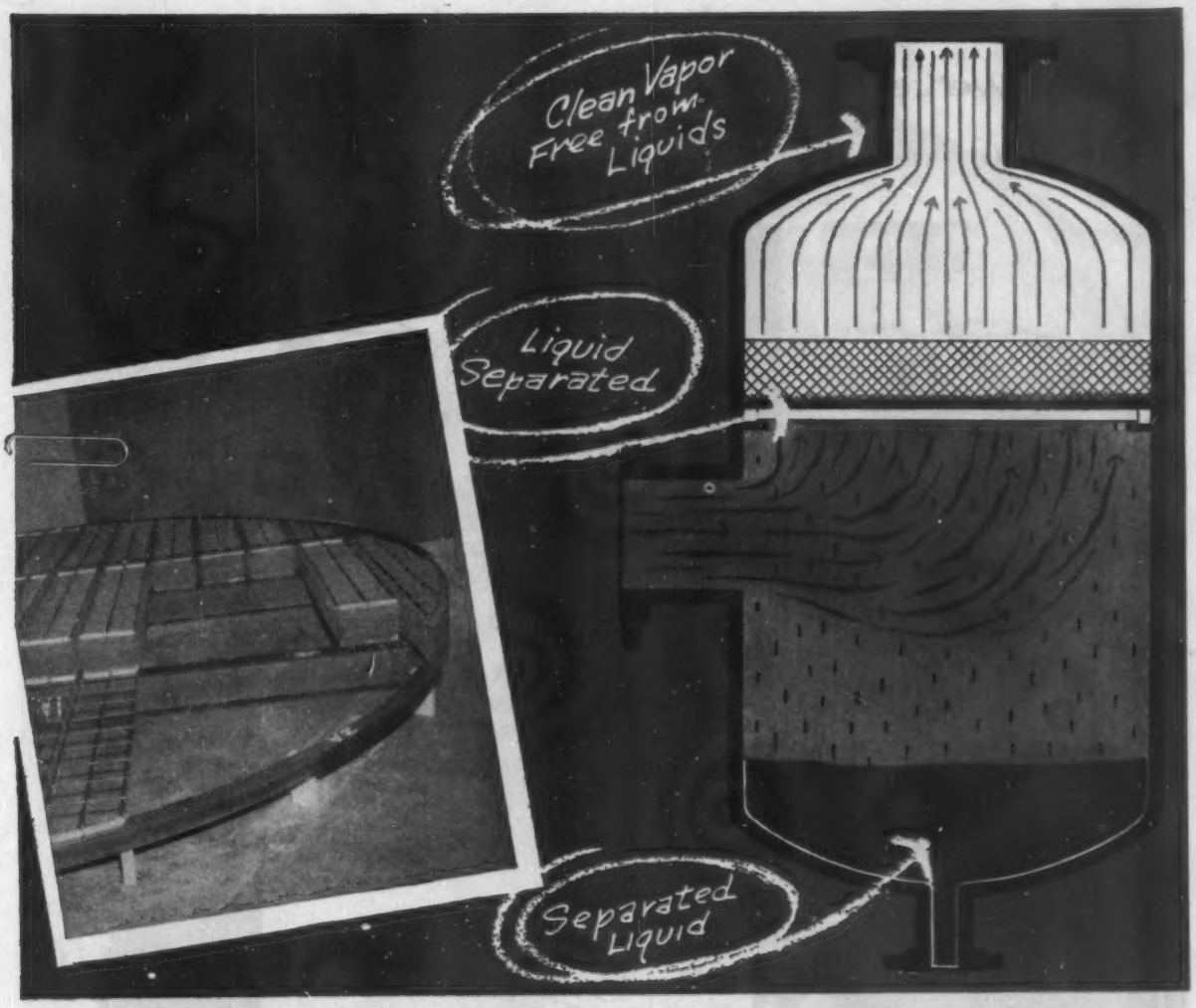

How to IMPROVE Process Vessel PERFORMANCE

By effecting clean separation of liquid from vapor Yorkmesh Demisters improve process vessel performance.

In **distillation equipment** liquid entrainment is controlled, giving better quality overhead products even at increased thruput rates.

In refinery **vacuum towers,** higher quality gas oil means higher conversion rates to gasoline in the cat cracker.

In **absorbers,** loss of absorbing liquid is prevented.

In **separator vessels** and **knock-out drums** greater liquid recovery results.

In compressor **suction drums,** complete liquid separation decreases compressor maintenance.

In **evaporators,** by controlling liquid carry-over product loss is avoided, and high purity condensate is suitable for boiler feedwater or process use.

In **steam drums** the result is clean, dry steam.

In **vent stacks** Yorkmesh Demisters contribute to the solution of air pollution problems.

Write for Bulletin 17 and a complete list of the many case histories available from our technical library.

YORK

OTTO H. YORK COMPANY, INC.
6 Central Avenue, West Orange, N. J.

Specialists in FLUIDS SEPARATION / ENGINEERS and MANUFACTURERS

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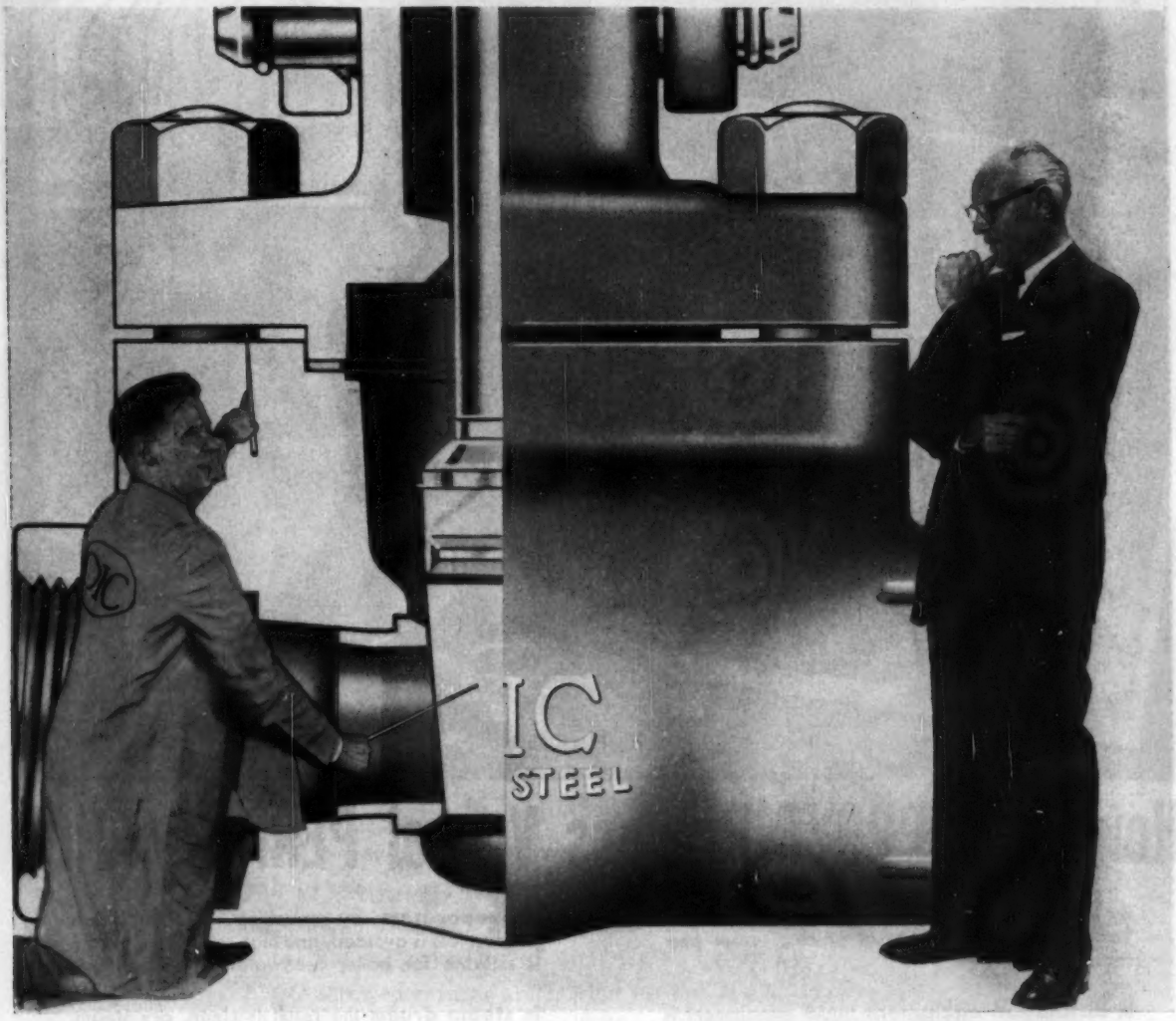
...and you can see here....and here, how we've killed maintenance problems on our new forged steel lines.



We stop galling and erosion by giving you 13% chrome stainless steel trim with wedges *duracased* to a rugged *1000 Brinell hardness*.

The square and *bolted* body-bonnet joint makes it easy to service the valve quicker. And it's a tighter joint, made doubly leakproof by recessing the soft iron gasket into the body. The gasket can't blow!

And you get the fastest joint make-up you've ever seen. Look at those pipe ends. See the extra wrench-gripping area and lugs. See how body-bonnet flanges are out of the wrench's way. No time lost here!

These new 600-lb. OIC forged steel valves are available with either *high-flow* ports (1300 line), or *standard-flow* ports (1100 line). Call your OIC Distributor, or write for specification literature.

The Ohio Injector Company • Wadsworth, Ohio

OIC VALVES | BRONZE, IRON, FORGED AND CAST STEEL, LUBRICATED PLUG VALVES

NO. 4 ACME SYNCHRO SHUTTER
1 2 5 10 25 50 100 150 B T
MADE IN U. S. A. BY ILEX OPTICAL CO. FOR EASTMAN KODAK COMPANY, ROCHESTER, N.Y.
45 32 22 16 11 8 6.3

keep gum formation out of the picture with... Tenamene

EASTMAN GASOLINE ADDITIVES

Your gasolines deliver the performance you build into them when Tenamene additives are present to guard against power-robbing gum formation.

The Tenamene line includes every principal type of gum inhibitor in commercial use today.

The quality and uniformity of the Tenamene additives are assured since Eastman manufactures all of the gasoline additives it supplies and exercises precise control over every step in the manufacture of them.

On-the-spot technical service is available from qualified Eastman petroleum specialists to help you achieve maximum performance from these dependable additives.

For more information on Tenamene additives and the service that backs up their proper use, contact our local representative or write to EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

SALES OFFICES: Eastman Chemical Products, Inc., Kingsport, Tennessee; New York City; Framingham, Mass.; Cincinnati; Cleveland; Chicago; St. Louis; Houston. **West Coast: Wilson Meyer Co.,** San Francisco; Los Angeles; Portland; Salt Lake City; Seattle; Denver; Spokane; Phoenix.

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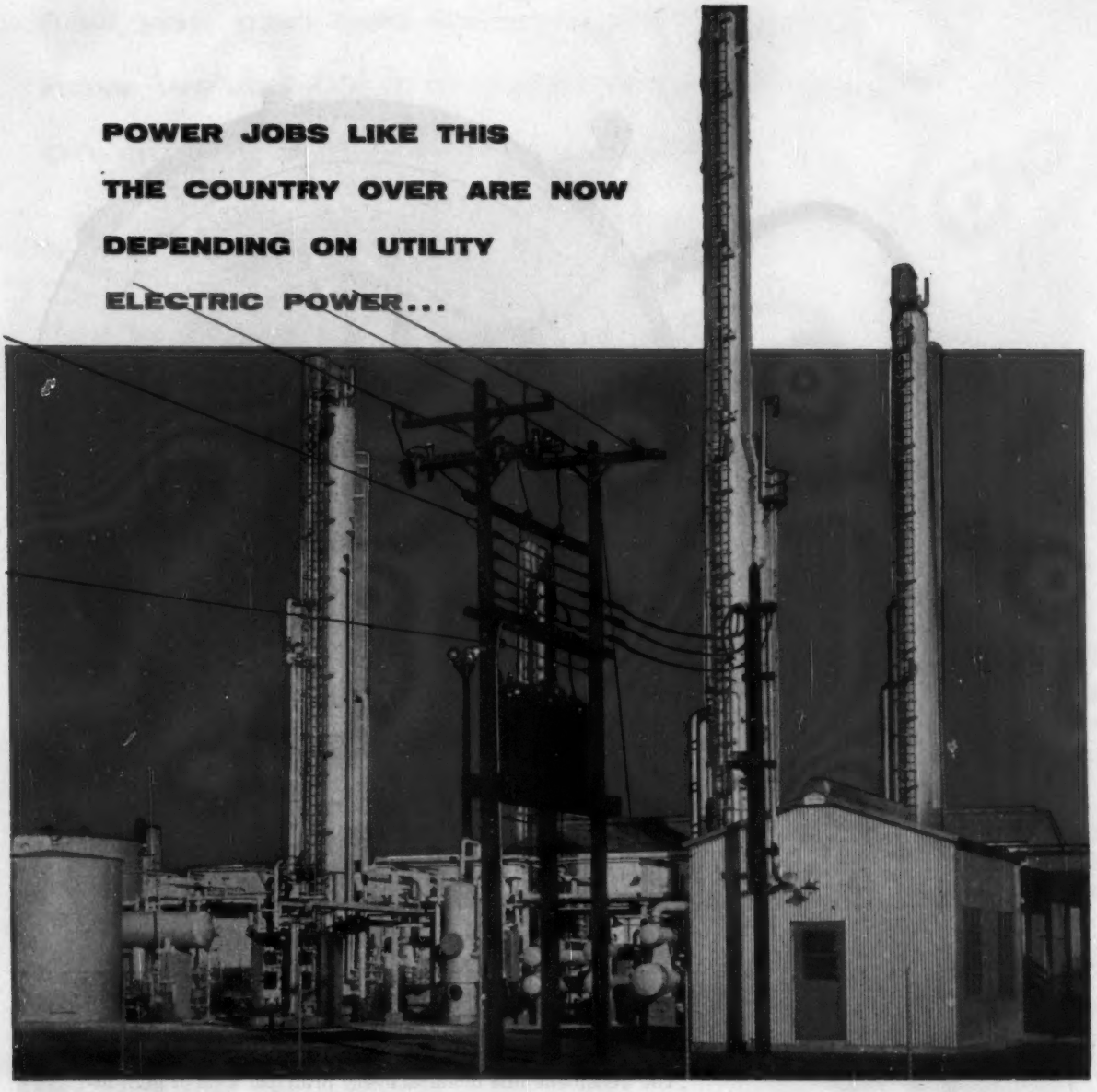
POWER JOBS LIKE THIS THE COUNTRY OVER ARE NOW DEPENDING ON UTILITY ELECTRIC POWER...



Progressive Management is taking a second look

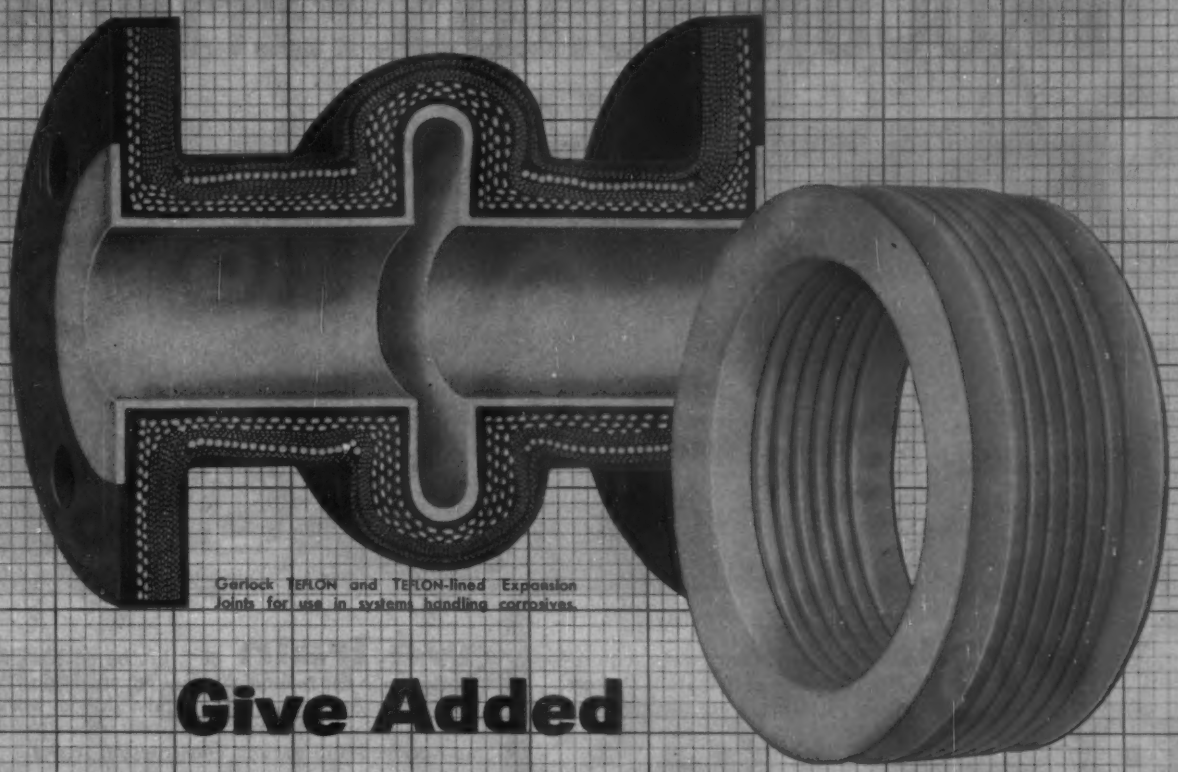
One of the biggest expansions in refining operations is coming up. If you have any part in this important development don't let your company decide on power until the modern benefits of UTILITY ELECTRIC POWER have been carefully investigated. Call in the sales engineer of your Electric Service Company while your plant is in the planning stage. Convincing facts and helpful counsel are yours for the asking.

Be modern . . . Be progressive . . .
Use UTILITY ELECTRIC POWER.

PETROLEUM ELECTRIC POWER ASSOCIATION

P. O. BOX 35006 DALLAS. TEXAS

MORE OF THE GARLOCK **2,000**



Garlock TEFLON and TEFLON-lined Expansion Joints for use in systems handling corrosives.

Give Added IMPACT RESISTANCE to costly piping

Garlock Expansion Joints protect your costly piping from damage caused by shock, vibration, expansion or contraction. TEFLON Expansion Joints are recommended when corrosives such as acids, caustics, or solvents are being handled. TEFLON-lined Expansion Joints are used in higher pressure systems handling corrosives. All-rubber expansion joints are recommended for water, mild acids, mild caustics, air or exhaust steam at temperatures up to 180°F. The right size and type is available for handling any liquid or gas.

Expansion joints are another important part of "The Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals for every need. The only complete line. Ask your Garlock representative for his unbiased recommendations or write for Expansion Joint Folder AD-137.

Cutaway of Garlock All-Rubber Expansion Joint shows steel reinforcing rings which vary in number with size. These Joints are available in sizes from 1¾" dia. to 18 feet in diameter.

THE GARLOCK PACKING COMPANY, PALMYRA, N. Y.
For Prompt Service, *Contact one of our 30 Sales Offices and Warehouses throughout the U. S. and Canada.*

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

PROCON BUILDS REFINERY

we plan the refinery, every requirement, every detail is carefully anticipated. Process units that will perform as required are incorporated into an efficient design.

we train 85% of the native Cuban workmen in the technicalities of construction. These men were developed into highly skilled workers, other previously trained mechanics were up-graded and perfected in various construction trades.

we solve some tough problems. 1 and 2. Prefabricated crude atmospheric column was unloaded and floated ashore overcoming expensive and time-consuming transport problem. 3. Prefabricated panels go on Platformer and crude heaters. 4. Some of the foundations and piping trenches were blasted from solid rock.

For more data on advertised products, use Readers' Service Cards, last page.

FOR TEXACO IN CUBA

And here's how we did it . . . Solving challenging construction problems proves Procon's ingenuity.

It's a pretty exacting business at best, building a refinery from scratch. Add a double handful of natural, geographical and human problems to it and you've got a fairly clear picture of the challenges Procon met and overcame to give The Texas Company (West Indies) Limited this handsome refinery, the first ever built in eastern Cuba.

The pictures you see here tell some of the story of how this 20,000 BPSD refinery was built by Procon three miles south across the bay from Santiago.

If you have a refinery in mind . . . or a petrochemical plant, or a chemical plant or individual process units for any of these . . . you can be sure of top-flight construction anywhere in the world when you call on Procon to do the job.

PROCON *International, S. A.*

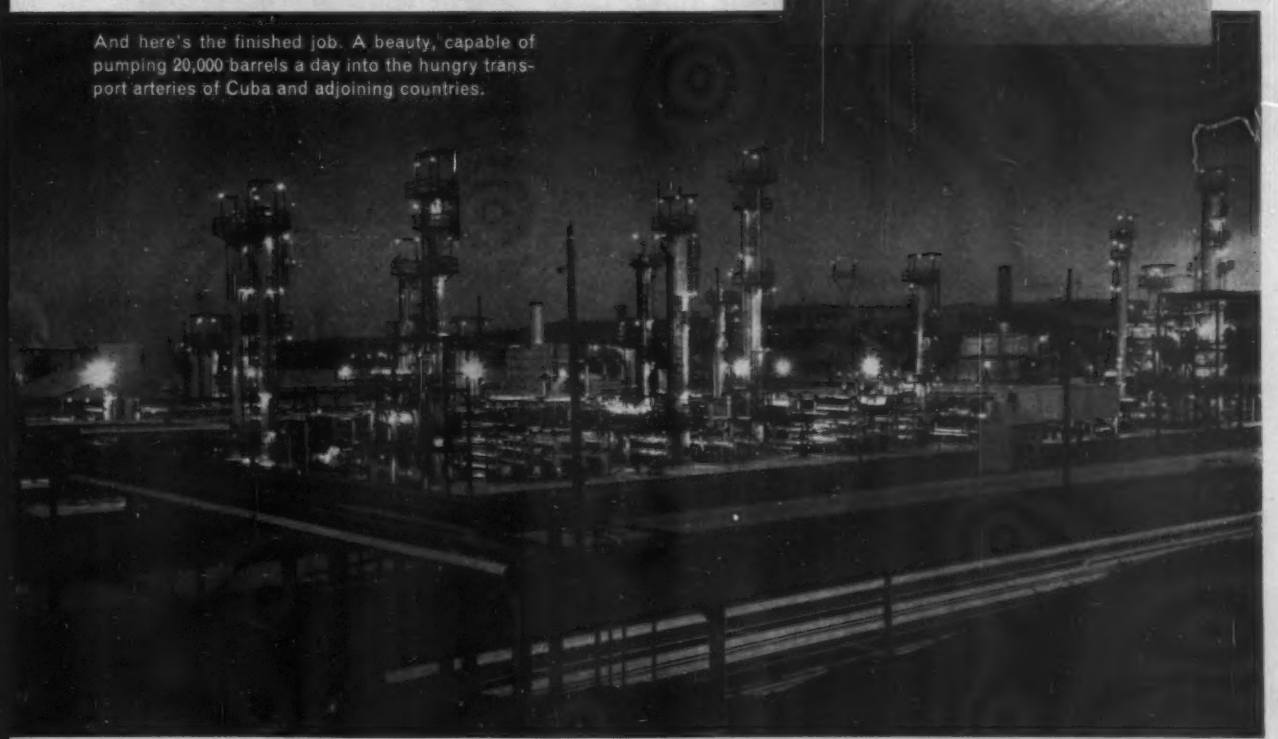
JOSE A. SACO. NO. 6. SANTIAGO DE CUBA

PROCON INCORPORATED. DES PLAINES. ILLINOIS. U. S. A.
PROCON (CANADA) LIMITED. TORONTO 18. ONTARIO. CANADA
PROCON (GREAT BRITAIN) LIMITED. LONDON. W. C. 2. ENGLAND

WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES

The refinery is served by a deep-water dock that accommodates two tankers simultaneously. Procon laid a 24-inch crude line and auxiliary piping to pipe feed stock directly into processing area.

And here's the finished job. A beauty, capable of pumping 20,000 barrels a day into the hungry transport arteries of Cuba and adjoining countries.



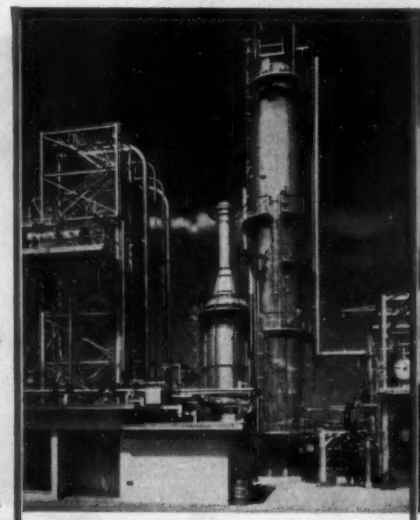
For more data on advertised products, use Readers' Service Cards, last page.

How Blaw-Knox provides a complete service for every phase of petroleum processing

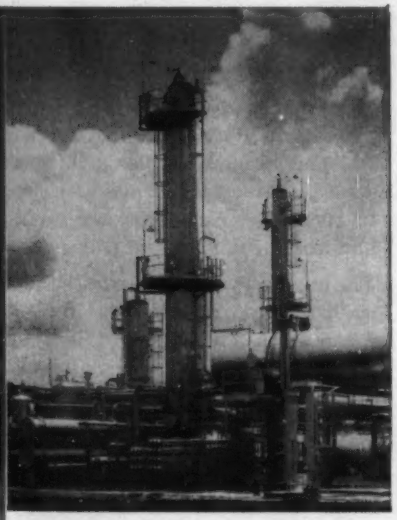
Backed by extensive engineering and construction experience in all phases of the petroleum industry, Blaw-Knox provides an integrated program for projects of varying size and scope.

Design and development facilities include: Plant site surveys • Process engineering • Equipment procurement • Cost control reports • Complete construction • Initial operation

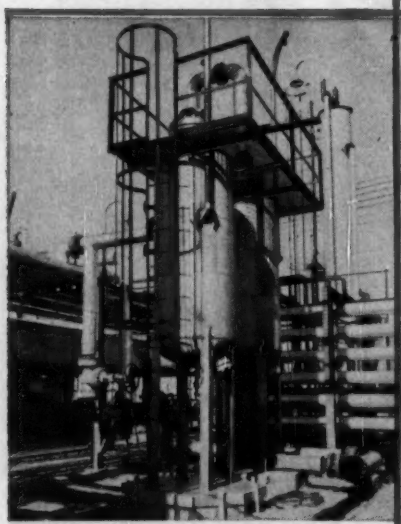
We shall be glad to explore any processing problem, new plant plans or modernization program that you are considering.



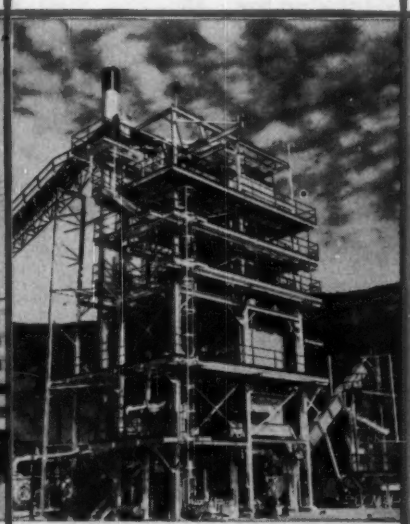
Decarbonizing unit, an exclusive Blaw-Knox development for increasing coking efficiency, lowering costs and improving basic processing procedures.



Alkylation—using sulfuric acid or hydrofluoric acid is one of the many modern intermediate processes supplied by Blaw-Knox.



The world's first Unifining unit, built by Blaw-Knox, improves distillate feed stocks and boosts quality in the product finishing segment of the industry.



This shale retorting plant demonstrates Blaw-Knox leadership in developing future oil sources as well as improving today's processing techniques.

For more information, send for Bulletin 2547, "Petroleum Processing Plants." It describes Blaw-Knox services and reviews results achieved for the industry.

BLAW-KNOX

BLAW-KNOX COMPANY

Chemical Plants Division

Pittsburgh 22, Pennsylvania • Chicago 1, Illinois

Birmingham • New York • Philadelphia • San Francisco • Washington, D.C.

long-run power by Allis-Chalmers

If you specify "Allis-Chalmers motors or equal"

. . . remember that the "equal" is possible only in two respects: price and nameplate specifications. You can't match the *long-run power* of Allis-Chalmers motors.

Double-shielded bearings guarded against dirt and over-greasing . . . provision for elimination of moisture condensation . . . practically indestructible rotor design . . . more cooling surface . . . more iron and copper content — these are the features (with others) that make up long-run power. These are the features that give Allis-Chalmers motors "plus" performance that can't be equalled.

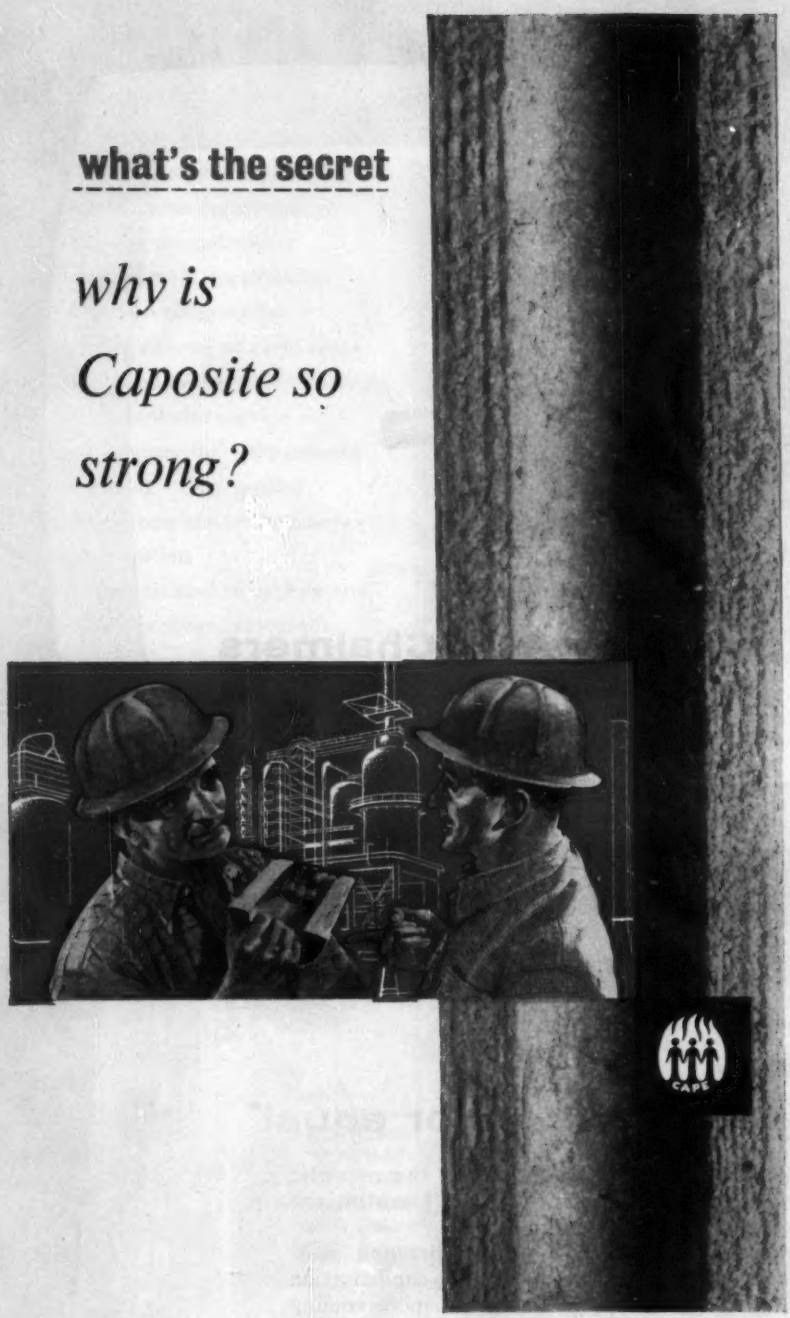
Find out more about the motors with long-run power from your A-C representative or distributor, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-5663

what's the secret

why is Caposite so strong?



It's no secret why CAPOSITE insulation is so strong and stands up to such rough usage. These pipe sections and blocks are made wholly of Amosite asbestos and the long fibres of this particular kind of asbestos give CAPOSITE its strength and resilience as well as its high insulating value. This exceptional strength leads to many other features besides long life; it means that larger sizes of pipe sections and blocks are possible, making application easier and faster. Less care is needed in handling the material. Unlike other moulded insulation, CAPOSITE, because of its strength, can be shipped to refineries anywhere in the world *in cardboard cartons*, showing big savings in freight and storage costs.

CAPOSITE Regd.

ASBESTOS INSULATION

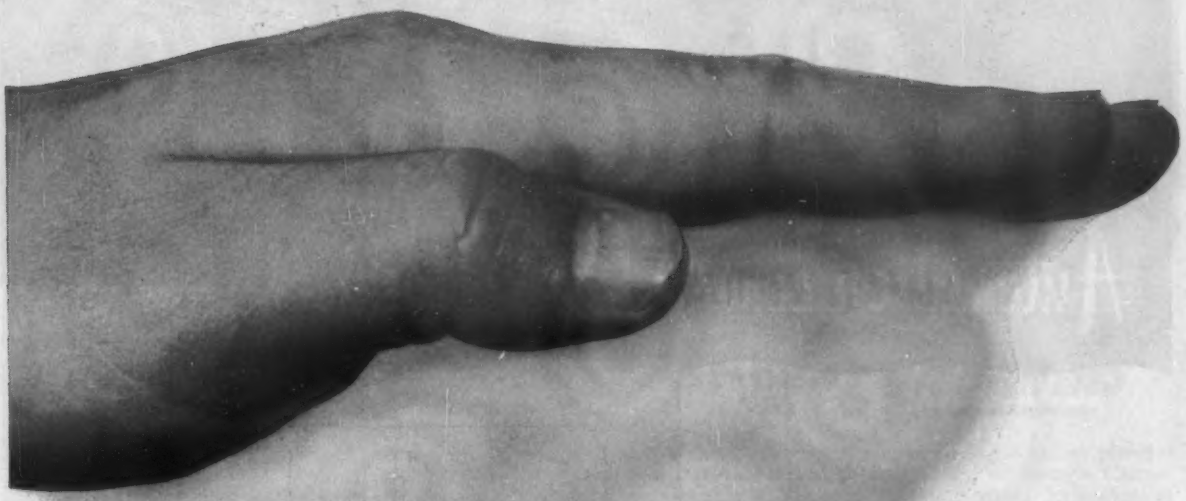
THE CAPE ASBESTOS COMPANY LIMITED, 114 & 116 PARK STREET, LONDON W1 Tel: Grosvenor 6022 Cables: Incorrupt London

Enquiries in Canada to: Cape Asbestos (Canada) Limited, 200 Bloor Street East, Toronto, Ontario
U.S.A.: North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois

TA 10643

new **S&J** *Breather Valves*

Materially Reduce Storage Tank Vapor Loss



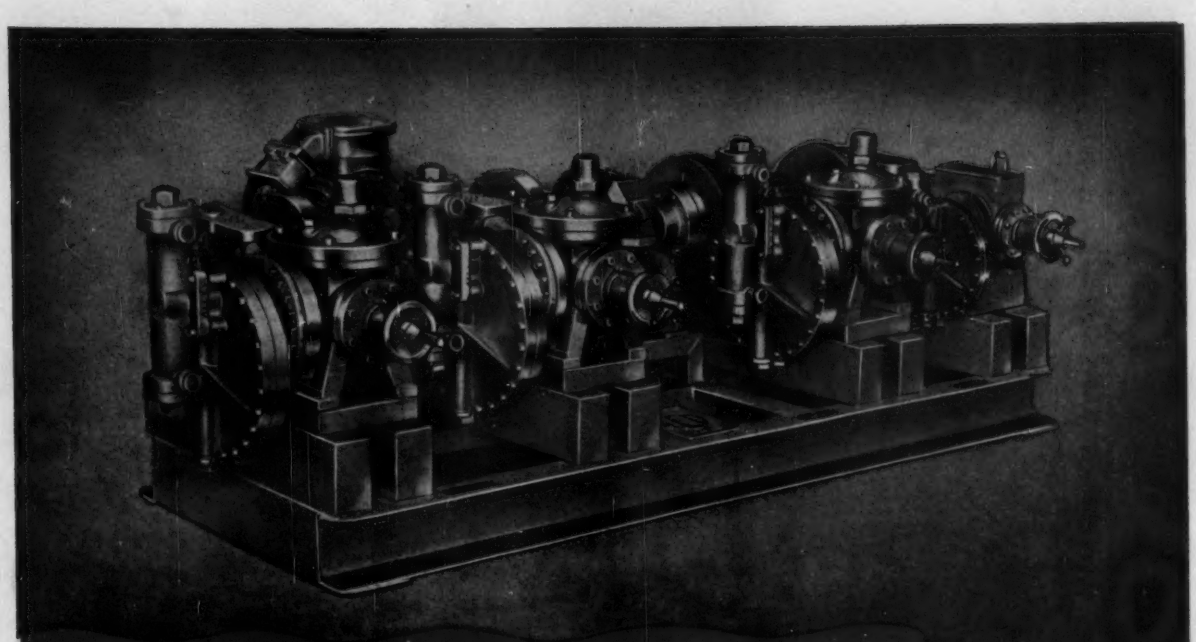
New Shand and Jurs model ST-9749 diaphragm-type breather valves are a major achievement in storage tank venting and vapor conservation. They provide resistance to sticking, corrosion and freezing never before offered. In addition they require practically no maintenance feature non-wetting teflon-on-fiberglas diaphragms for maximum performance and longer life; completely eliminate critical drain holes or other areas that require continuous checking. Ruggedly built from aluminum and stainless steel, ST-9749 breather valves are lightweight, and already available in 4", 6", 8", and 10" sizes. Call your nearest S&J branch office or sales representative for Technical Bulletin 52D-ST-9749 Breather Valve.

SHAND AND JURS

GENERAL PRECISION EQUIPMENT CORPORATION GPE

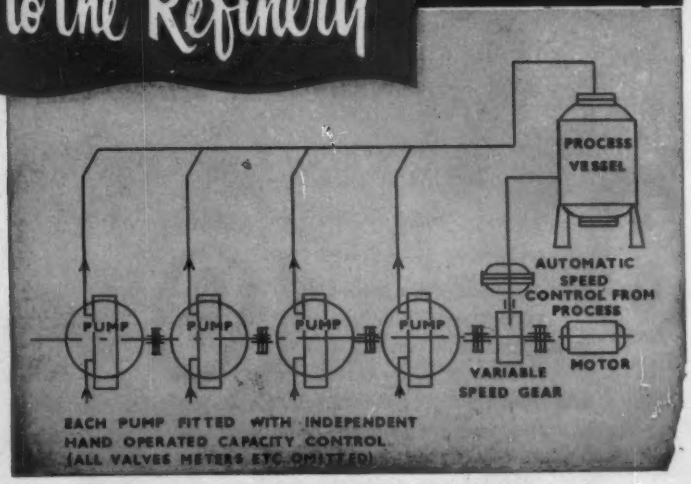
2600 Eighth Street, Berkeley, California
Branch offices and representatives in principal cities

For more data on advertised products, use Readers' Service Cards, last page.



Automation comes to the Refinery

The above photograph illustrates an assembly of four hydraulically operated piston-diaphragm pumps of various capacities, each fitted with micro capacity control.



The pumps are driven by one motor through a variable speed hydraulic gear box fitted with standard pneumatic diaphragm head connected to the control so that the speed of the complete unit can be varied from zero to full by a signal pressure from 3 to 15lb. per square inch. This in conjuction with the individual capacity control on each pump enables the rate of delivery of any mixture to be automatically controlled from the process plant.

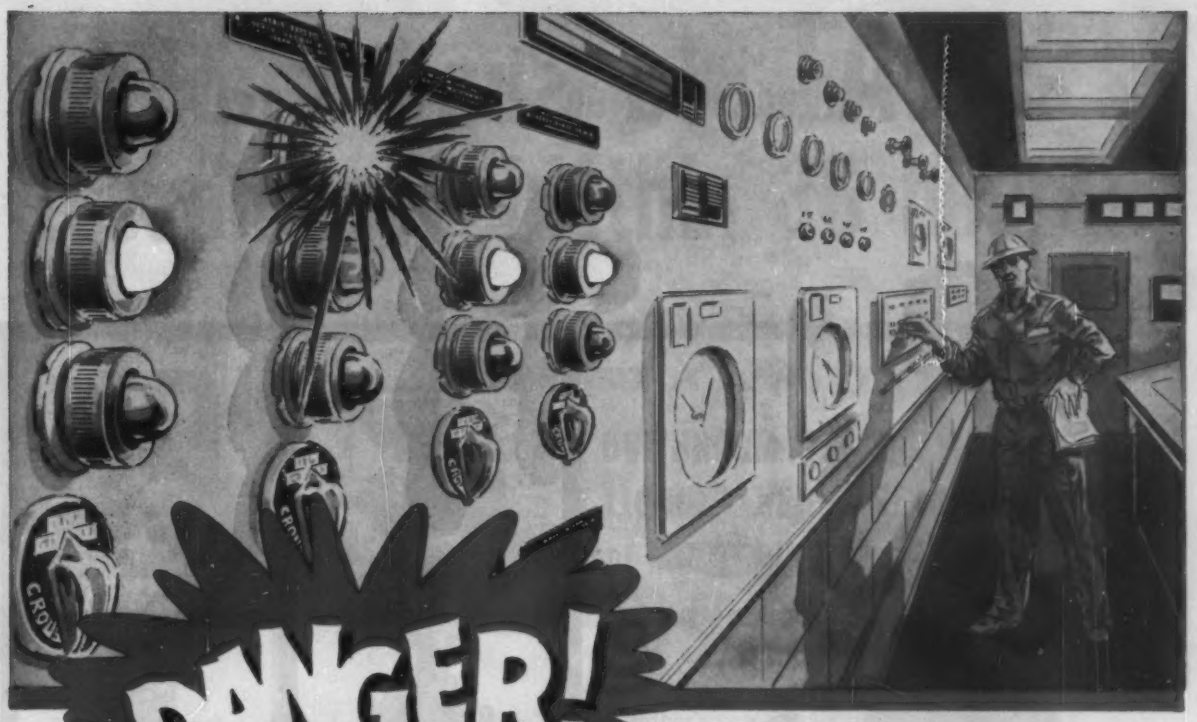
E.C.D. LTD TONBRIDGE · KENT

E.C.D. LIMITED · ENGINEERS

TONBRIDGE · KENT · ENGLAND

Telephone: Tonbridge 2237 (3 lines)

Telegrams: Tonmil, Tonbridge.



. . . instantly signaled by Crouse-Hinds *Visularms*®

In oil refineries, chemical plants, synthetic rubber plants — wherever constant watch of processing is necessary — Crouse-Hinds Condulet® *Visularms* provide visual indication of process conditions, and instant control of manufacturing equipment.

By means of pilot lights (and bell, horn or siren signals where desired) *Visularm* indicates normal or abnormal temperature, liquid level, pressure, or other conditions which can be electrically coupled to the circuit.

Explosion-proof or dust-tight and weather-resistant construction* assures maximum safety in hazardous locations. Compact designs minimize space required on control or panel boards . . . are easy to install.

A Visularm system delivers substantial savings by eliminating the necessity for buying individual components . . . housing them . . . and wiring your own system completely.

Two- or three-light styles may be mounted either vertically or horizontally. For audio warning, any number of *Visularms* may be used to operate a single horn, bell or siren.

Visularms are just one of hundreds of items in process control board equipment offered by Crouse-Hinds. Only a few are shown at left. For full information on the complete line, call your nearest Crouse-Hinds distributor, or write . . .

*Dust-ignition-proof.

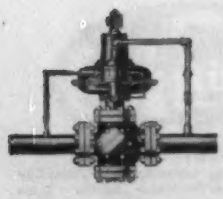
A NATIONWIDE DISTRIBUTION exclusively through ELECTRICAL DISTRIBUTORS

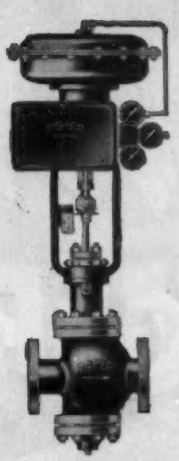
CROUSE-HINDS COMPANY

Main Office and Factory: Syracuse, N. Y.
Crouse-Hinds Company of Canada, Ltd.: Toronto, Ont.

Offices: Baton Rouge Birmingham Boston Buffalo Chicago Cincinnati Cleveland Corpus-Christi Dallas Denver Detroit Houston Indianapolis Kansas City Los Angeles Milwaukee New Orleans New York Philadelphia Pittsburgh Portland, Ore. Salt Lake City St. Louis St. Paul San Francisco Seattle Tulsa Washington RESIDENT REPRESENTATIVES: Albany Atlanta Baltimore Charlotte Chattanooga Jacksonville Reading, Pa. Richmond, Va. Shreveport.

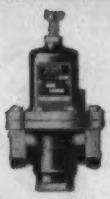
WHAT...a "super market" in this business?



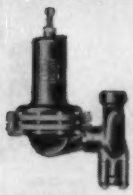


Type 657 with 3500 Positioner

Type 4150 and 4160 Wizard II Pressure Controllers

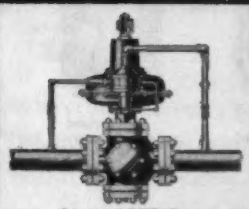


Type 95 Pressure Reducing Valve



Type 630 "Big Joe" Field Regulator

Series 99 Multi-Purpose Gas Regulator

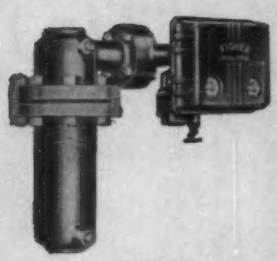


Series 298T Gas Regulators

Type 655-A Pressure Regulator

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

YES! *now you can shop by phone, wire or TWX...* for shipment within 36 hours!

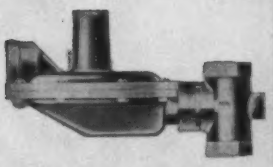


Series 2500-249 and 259B Level-Trols Cage Sizes 14" and 32"

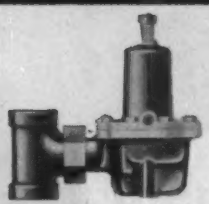
FACTORY STOCK ALWAYS ON HAND:

- Large stock of **DIAPHRAGM CONTROL VALVES**
- Wide choice of **LIQUID LEVEL CONTROLLERS**
- Assorted types of **MULTI-PURPOSE REGULATORS**

Type 75 Water Reducing Valve



Series S100 and 730 Service Regulators



Series 620 and 621 Farm Tap Regulators

Type 92B Pilot Operated Steam Reducing Valve

Series 67FR Combination Filter Regulator

Fisher's new special service department is organized much like a super market to help you meet emergency requirements with dispatch and speed.

A stock of the popular and standard diaphragm control valves, Wizard Controllers, level-trols and all types of gas regulators are kept on the shelf at all times ready to go.

Every Fisher representative receives a weekly list of all available types for the following week.

Now, when you're up against an emergency, phone, wire or TWX (Marshalltown 578 or 579) the factory or your Fisher representative ... your order will be enroute within 36 hours (except Saturday and Sunday) after it is received in Marshalltown.

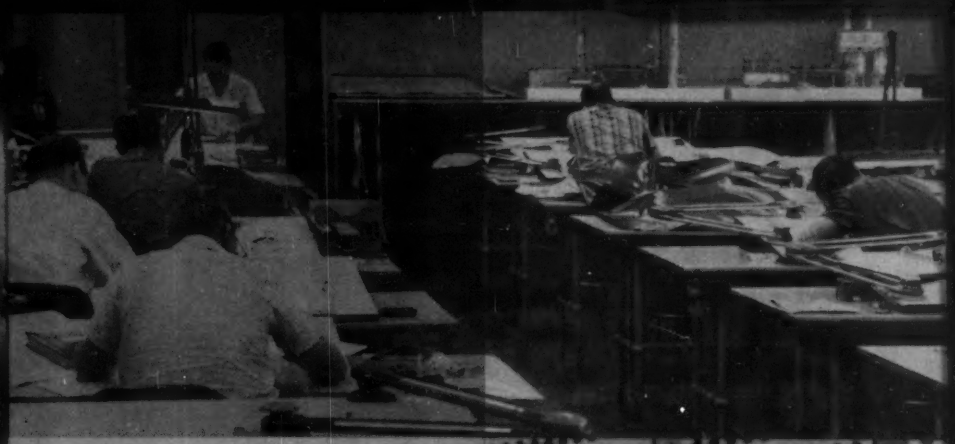
FISHER® Controls

SINCE 1880

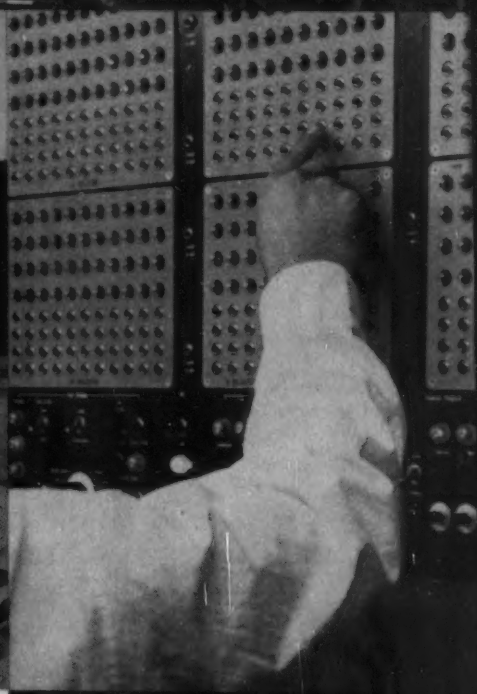
FISHER GOVERNOR COMPANY

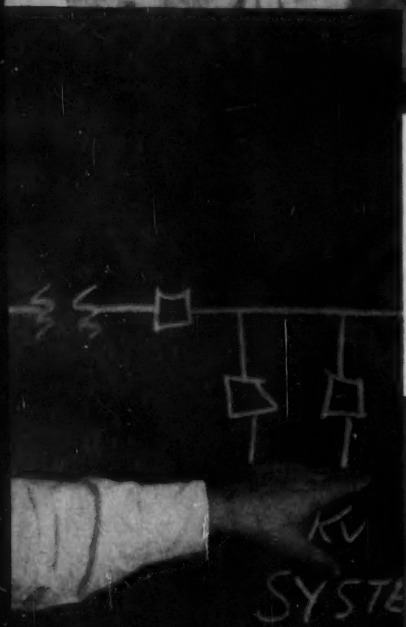
Marshalltown, Iowa/Woodstock, Ontario/London, England

For more data on advertised products, use Readers' Service Cards, last page.



Fluor's Datatron digital computer frees engineers from routine computation, permitting full use of their creative design talents. Its ability to quickly perform intricate calculations without error shortens engineering lead time . . . assures maximum precision and efficiency in completed plants.

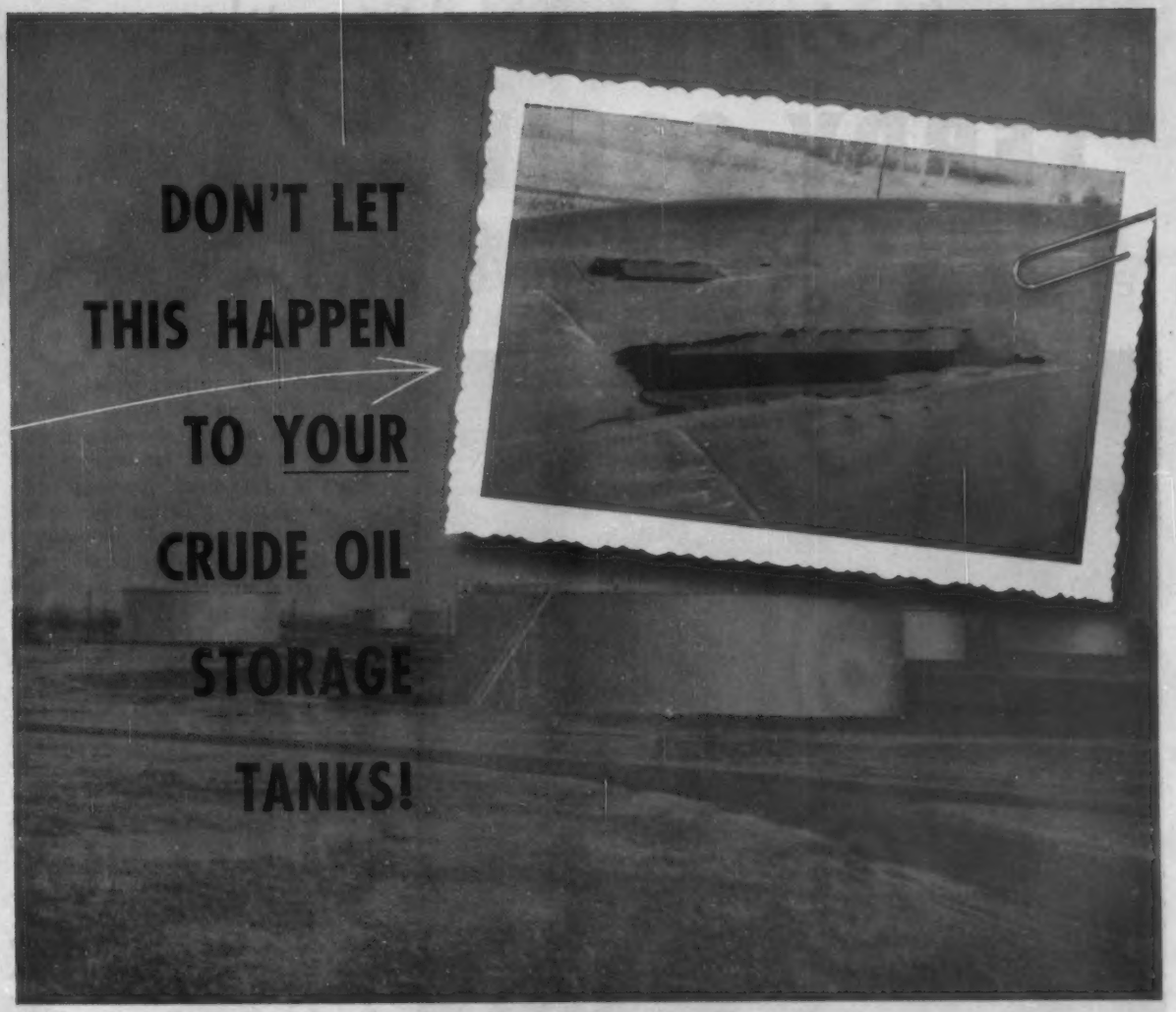




***WHEN** you consider expansion...*
the most important investment
you can make is in
the creative ability of men.

FLUOR

The Fluor Corporation, Ltd.
Engineers & Constructors
2500 S. Atlantic Blvd., Los Angeles



Protect them with Pitt Chem

TARSET®

RIGHT *now*—as you read this—corrosion may be destroying thousands of dollars worth of your petroleum handling and storage equipment. It happens every day, as witness the photograph of the crude oil storage tank top, above.

Now—for the first time—you *can* control these costly corrosion losses with a practical and relatively economical protective coating—Pitt Chem "Tarset." Backed by three years of service experience, Tarset combines the best qualities of two of industry's most effective and proven protective materials—*coal tar* and *epoxy resin.*

Tarset is the kind of a rugged, heavy duty coating you want. It will not shatter at −30°F or soften at 400°F.

It is easy to apply by brush, spray or roller and adheres so well that it is almost impossible to remove from metal.

What's *your* crude oil corrosion problem? Our Pitt Chem engineers are ready to tackle it right now . . . and, if possible, come up with some dollar-saving answers for you. *Write or call us today!*

PITTSBURGH
COKE & CHEMICAL CO.

WSW 6088A

COAL CHEMICALS • PROTECTIVE COATINGS • PLASTICIZERS • ACTIVATED CARBON • COKE • CEMENT • PIG IRON

For more data on advertised products, use Readers' Service Cards, last page.

Here's a vertical turbine with

TERRY SOLID WHEEL

and all its advantages

When it comes to judging a turbine's ability to deliver in vertical service, ratings tell only half the story. It's the Terry construction refinements that give you assurance of long-range operational economy: Thrust bearing designed to absorb external pump thrusts ... carbon ring glands specially made for vertical operation ... casings and bearing housings split vertically for easy accessibility.

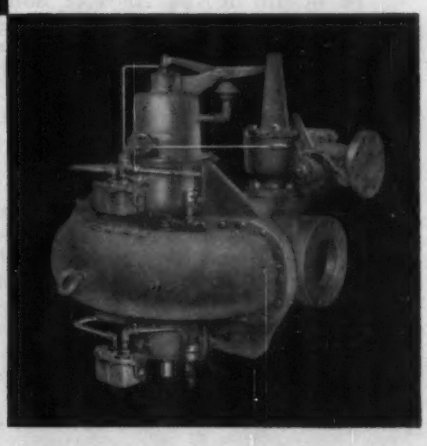
But most important, the Terry vertical turbine has an *almost* indestructible rotor. A single forging of special composition steel, it has no separate parts to loosen or work out. As the only function of the blades is to form a series of pockets, any wear which might occur would not materially affect horsepower or efficiency.

If your application demands a vertical turbine, specify Terry solid wheel. Available in capacities from 5 to 300 horsepower. And remember, the extra durability built into these vertical turbines is typical of every turbine in the complete Terry line.

For further information, send for a copy of bulletin S-137.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TERRY



TT-1210

For more data on advertised products, use Readers' Service Cards, last page.

Consolidated process converts sludge acid to fresh, 99% sulphuric

Consolidated Chemical's regeneration process converts the heaviest sludge acid of lowest concentration into pure, white, 99% sulphuric and returns it to service . . . at a saving. Turning problems into assets is typical of Consolidated, which has been a pioneer in sulphuric acid manufacture in the Gulf Southwest for almost 40 years.

Whether your requirement is for new acid or regeneration of spent acid, you will find the facilities and services you need at Consolidated Chemical's plants in Ft. Worth, Houston, Baytown, Baton Rouge, or Le Moyne, Ala.

Turn *your* disposal problem into an asset. Get information on point of shipment, price and delivery. You'll like doing business with Consolidated.

Stauffer CHEMICALS SINCE 1885

CCI

CONSOLIDATED CHEMICAL INDUSTRIES

DIVISION OF STAUFFER CHEMICAL COMPANY

6910 Fannin St.
Houston 25, Texas

380 Madison Avenue
New York 17, N. Y.

Why Suffer with Sulfur?

Less sulfur in the refinery stream means less corrosion and gum formation in process equipment . . . lower investment costs . . . less contamination of catalysts . . . less antagonism toward TEL . . . improved product odor, color, and stability . . . more profit in many ways for both the refiner and marketer.

Kellogg has the economic answer to high sulfur crudes. Working closely with the refiner's engineers, as it has done with those of leading oil companies on the East and Gulf Coasts—as well as in England, Belgium, France—Kellogg can design a unit to remove harmful sulfur compounds to almost any degree desired. In one typical instance, weight per cent was reduced from 0.84 to 0.08 in catalytic gas oil, and from 0.66 to 0.05 in furnace-oil distillate.

Optimum investment and operating costs are assured through designs that utilize selectively lower pressures, reduce the use of costly alloys such as 18-8, and lower the consumption of high pressure hydrogen.

Kellogg desulfurization units can be engineered to treat virgin streams of naphtha, kerosene, gas oil and other fuels, and cracked stocks of similar boiling ranges. Or units can be designed to operate simultaneously on streams from the topping and cracking units. Where desired, the design can include equipment to recover the sulfur as a salable by-product. Your inquiries will receive prompt attention.

REFINERY PROCESS DIVISION

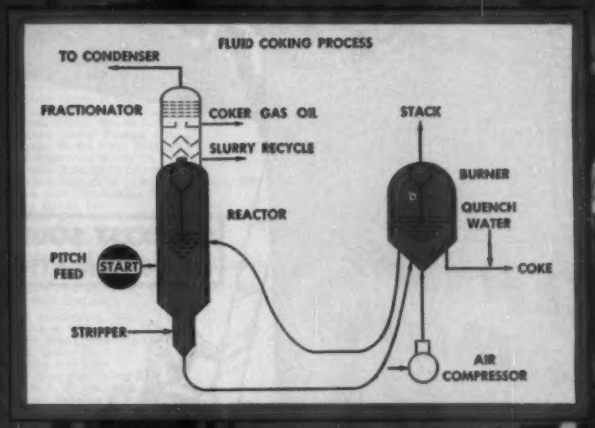
The M. W. Kellogg Company

711 THIRD AVENUE, NEW YORK 17, N. Y.

A SUBSIDIARY OF PULLMAN INCORPORATED

The Canadian Kellogg Co. Ltd., Toronto • Kellogg International Corp., London • Kellogg Pan American Corp., N.Y.
Societe Kellogg, Paris • Companhia Kellogg Brasileira, Rio de Janeiro • Compania Kellogg de Venezuela, Caracas

M KELLOGG W



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Esso Research and Engineering Company offers you *Fluid Coking*, the first successful fully continuous process for converting low value pitch into valuable lighter products. *Fluid Coking* actually handles the heaviest feed that can be pumped.

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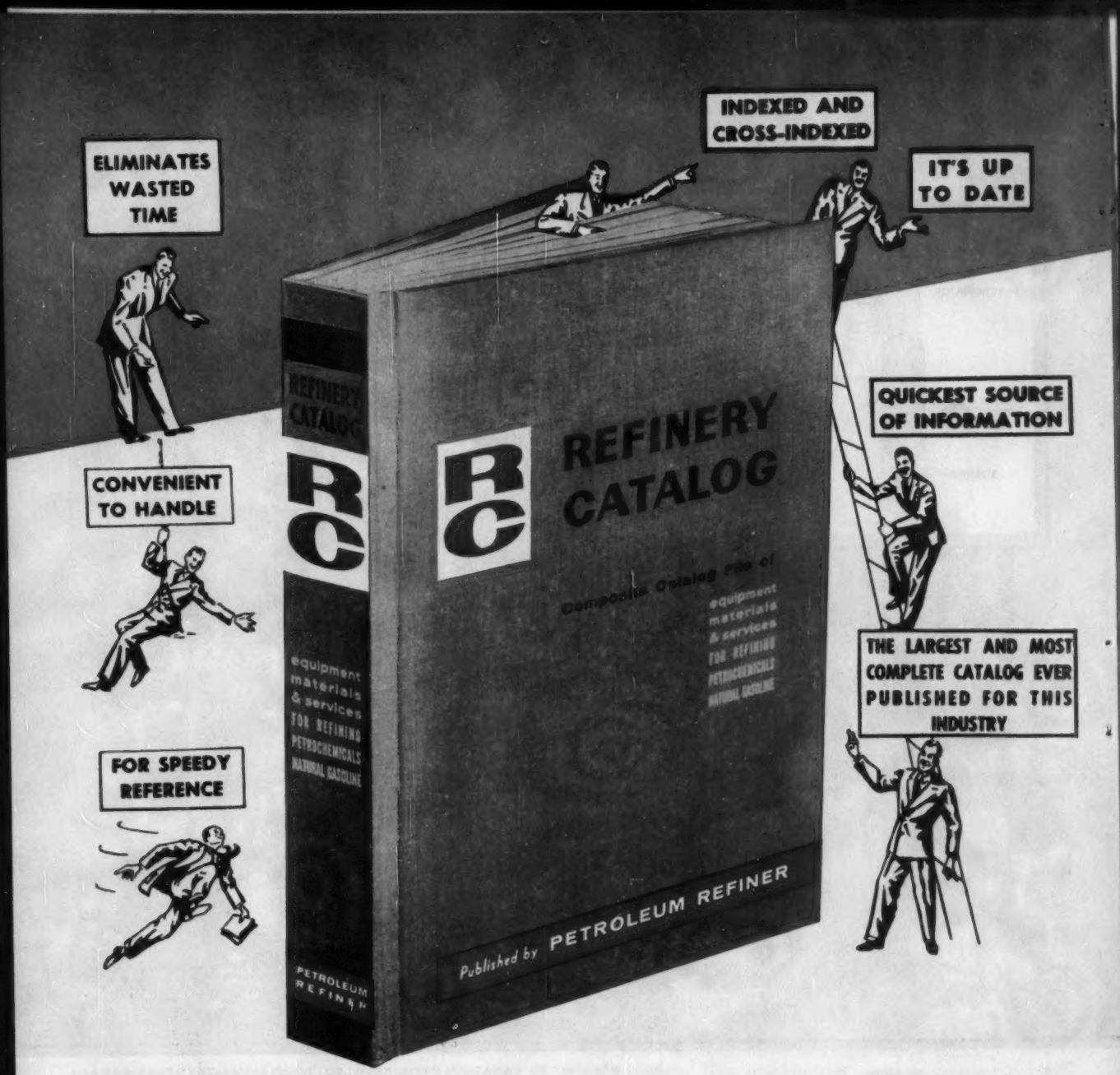
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The largest, most complete catalog ever published for the oil refining-processing industry, the new 1958 REFINERY CATALOG is serving as a genuine time-saver for operating executives, superintendents, foremen, engineers, purchasing agents and others who buy or specify equipment and supplies.

More than 300 leading manufacturers and suppliers have filed their complete or condensed catalog data in this edition. Compiled by the manufacturers themselves, this information is arranged and indexed to offer a quick and convenient means of locating items of equipment and services, and sources of supply of products in which you may be interested.

On the opposite page you'll find a complete list of companies whose complete or condensed catalogs appear in the current REFINERY CATALOG. When you're looking for data on products handled by these companies, be sure to check your REFINERY CATALOG. It is the most complete source of buying information available in one volume today.

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The electrically-shielded multiplane field, developed by Petreco engineers, removes salts, solids, and other impurities in the 98-100% range. This process is the result of 46 years of continuous development. Refiners throughout the world consider the Petreco all-electric desalters an integral part to crude oil processing.

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WANT MORE INFORMATION? *Write for additional literature, stating your particular interest or problem.*

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ALUMINUM GATE VALVES

by Darling

Darling gate valves of aluminum alloy offer all of the unique, extended-life features inherent with the Darling fully revolving double disc, parallel seat principle... for performance that assures unmatched economy... and freedom from leakage, trouble and downtime!

These Darling aluminum alloy valves are now available in ½" through 24" sizes. Write for full details, specifying your particular service requirements.

DARLING VALVE & MANUFACTURING CO.

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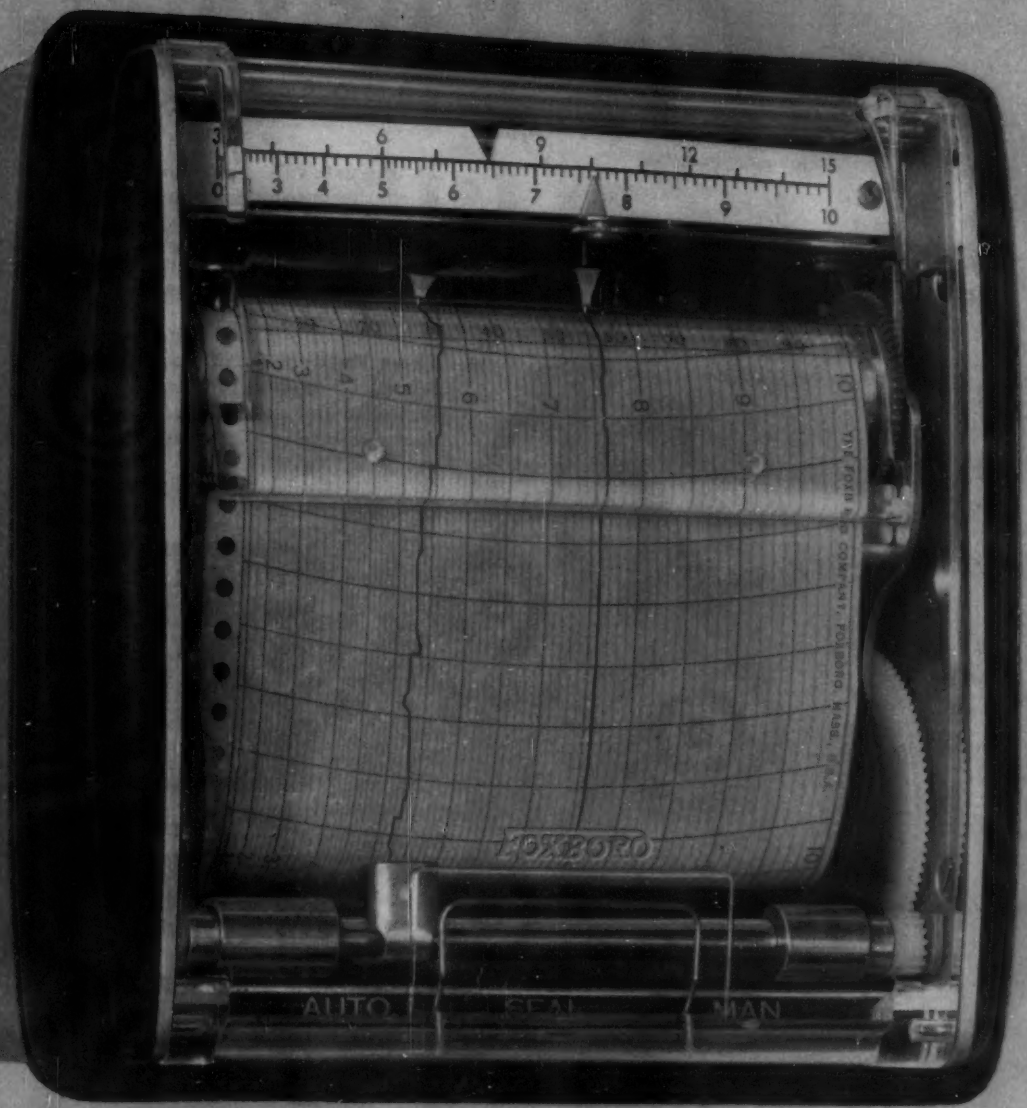
FOXBORO
adds new convenience features to CONSOTROL* Recording Control Stations



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– further "operating ease" combined with accuracy – readability – top performance

3-pen recording, angle mounting, indicating tear-off bar . . . just a few of the new convenience features you'll find in Foxboro Consotrol Recorders and Recording Control Stations.

But these new operating benefits are only part of the story. Additional control functions are handled easily with Consotrol Instruments. Auto-Selector control — the control of related variables through a common valve is now possible with Consotrol small-case panel instrumentation, as is centralized control of batch processes.

With their new, exclusive operating conveniences and process control functions, Foxboro Consotrol Recording Control Stations, now, more than ever, provide you with superior centralized recording and control. You'll find they maintain the highest standards of precision and dependability — are the simplest to maintain.

Write Foxboro for full details. Ask for Bulletin 13-18A. The Foxboro Company, 742 Neponset Ave., Foxboro, Mass., U.S.A.

FOXBORO

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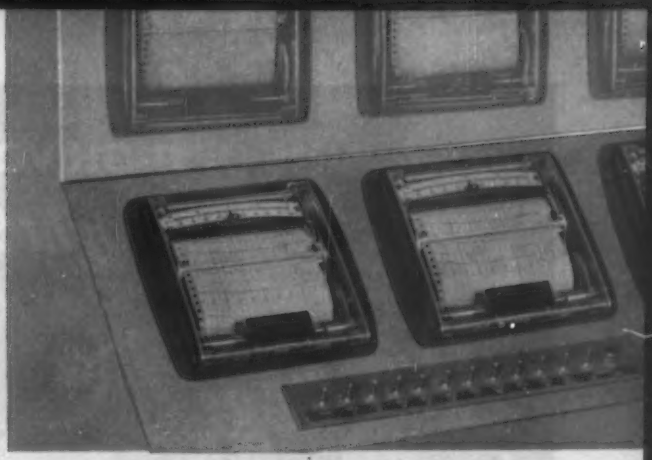
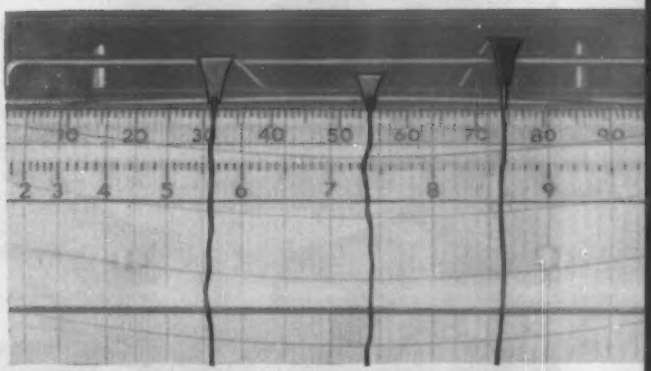
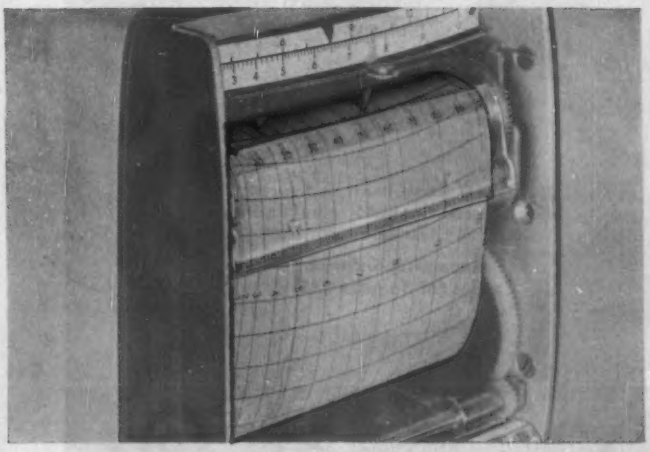


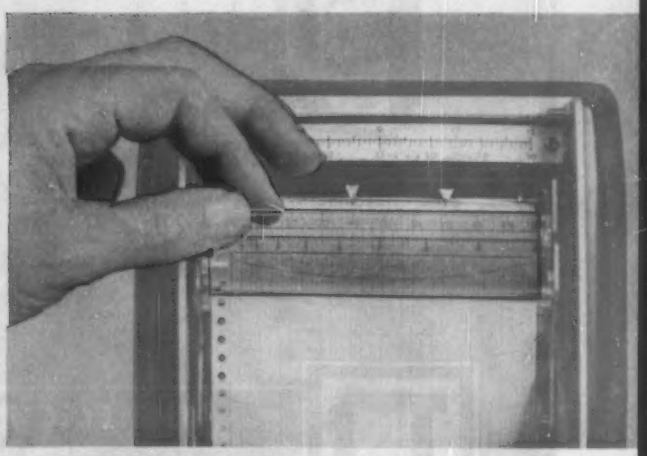
New – angle mounting Now you can panel-mount your Consotrol Recording Control Stations as much as 75° from the vertical, giving you more usable panel space closer to the floor. Operator can read lower instruments without stooping.



New – 3-pen recording 3 continuous records are simultaneously recorded on one chart, with this new Foxboro 3-pen recorder. Related measurements can be grouped for quick, easy comparison . . . valuable panel space is saved.



Full scale chart The Foxboro 4-inch Consotrol chart, with the same length scale as a 12-inch circular chart, travels vertically from the top. No sagging . . . no misalignment. Pen travels in same direction as circular-case recording pen.



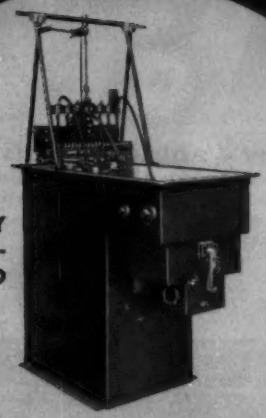
New – indicating tear-off bar Ideal for multi-pen control stations and recorders, this new "see-through" plastic tear-off bar has indicating scales to read second and third variables. Scale colors match pen colors – makes following a process a cinch for the operator.

EC&M's LINE OF HIGH VOLTAGE STARTERS GIVES YOU

*EXACTLY the Right Starter for Any Location!**

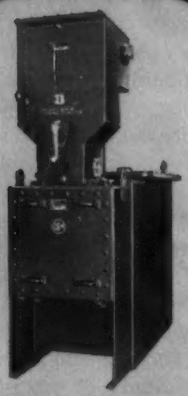
* Hazardous Location, Class I, Group D, Divisions 1 and 2

TOTALLY OIL-IMMERSED



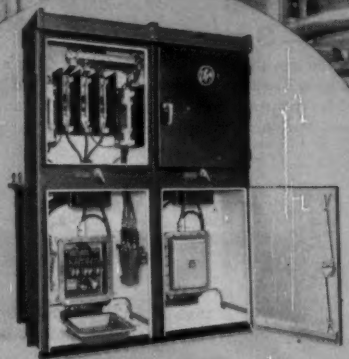
Type AT Combination Starter shown with Contactor and Overload Panel raised above the oil level without disconnecting any bolts or leads—in NEMA 3R enclosure for outdoor mounting, available in 50,000 KVA (certified) interrupting capacity.

OIL-IMMERSED



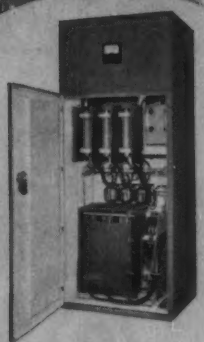
Type AM Combination Starter in NEMA 3R enclosure for indoor or outdoor locations—available in 50,000 KVA (certified) interrupting capacity —and VALIMITOR.®

OIL-BREAK



Type AH Combination Starter in NEMA 1 or 3R enclosures for indoor, outdoor or pressurized control room—available in 3 interrupting ratings, 50,000 KVA—POWER FUSED—and VALIMITOR.®

AIR-BREAK



Type AFG Combination Starter for Pressurized Control Rooms. Built in Class E1, Class E2 and VALIMITOR.®

For complete information write for Bulletin 8131-L

THE ELECTRIC CONTROLLER & MFG. CO.

A DIVISION OF THE SQUARE D COMPANY

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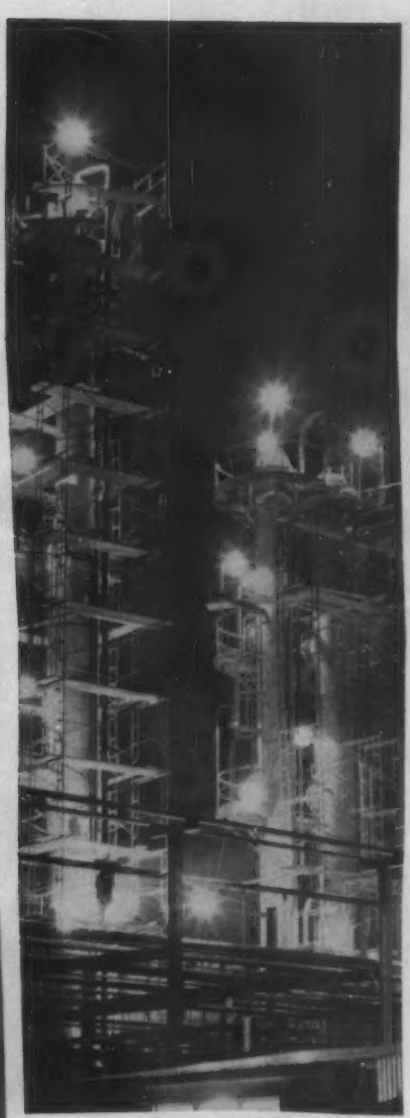
7928-R

Drastic reduction of heat loss with

PABCO PRECISION-MOLDED CALTEMP

a Calcium Silicate Insulation

When vapors or liquids are conveyed or held at temperatures up to 1900° F.—when equipment is operated to high heat levels—Pabco insulations cut heat losses to absolute minimums. "Precision Molded" by a patented process, Pabco's Caltemp and 85% Magnesia pipe and block insulations control temperatures within close tolerances. For data on technical advantages, case histories, or engineering consultation, write . . . or call a Pabco insulation engineer.



INSULATION GUIDE

Temperature	Recommended Pabco Insulation		
to 550°	85% Magnesia pipe covering	block	cement
to 1200°	Caltemp pipe covering	block	cement
to 1500°	Prasco 15 C pipe covering	block	cement
to 1900°	Prasco 19 C	block	

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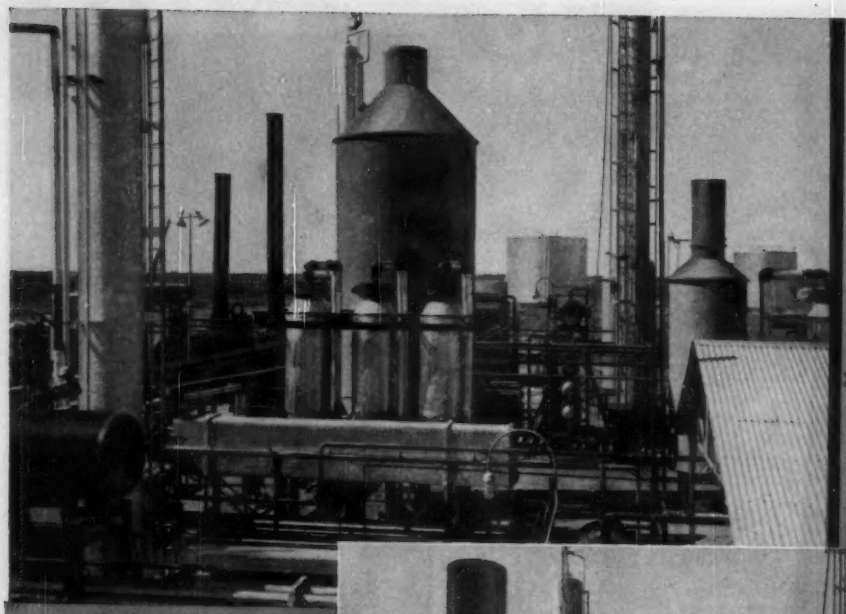
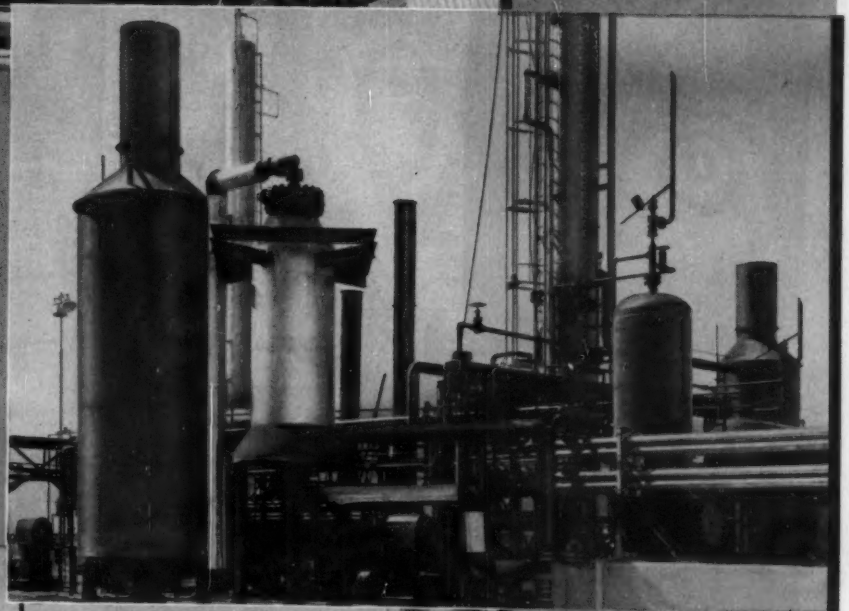
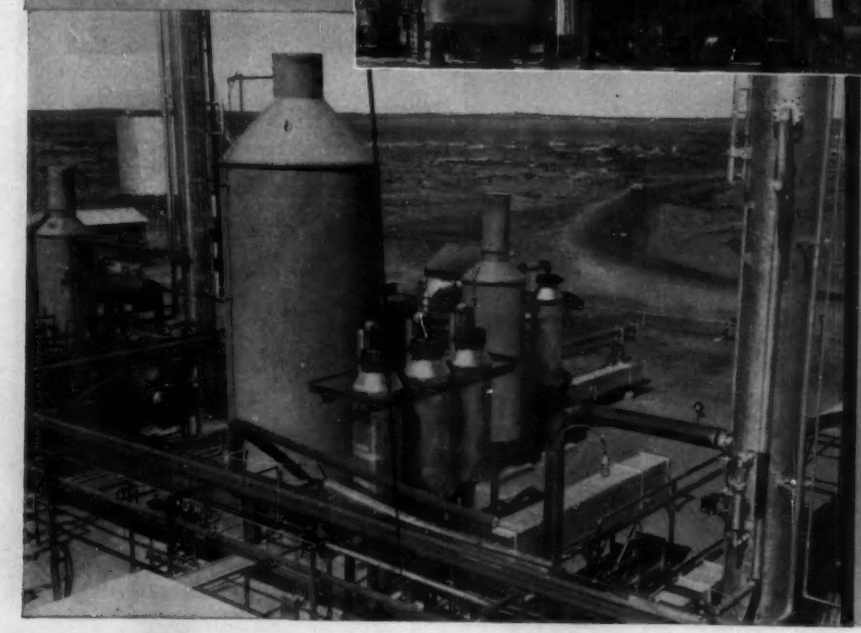
For more data on advertised products, use Readers' Service Cards, last page.



The vessel in the center is a gas fired updraft heater serving our Platforming unit. Three smaller vessels immediately in front of the heater are the Platforming reactors.



The vessel on the left is a heater and the structure on the right is a reactor of the UOP Unifining unit used in preparing the feed for our Platforming unit.



Shown here is the circular updraft heater and three reactors of our Platforming unit. Here you have an excellent view of the great New Mexico desert.

Famariss Produces High Octane Products From Platforming-Unifining Units

By Walter Famariss, Jr.
President
Famariss Oil and Refining Company
Hobbs, New Mexico

We have perhaps one of the smallest refineries marketing a finished product on the local level. Regardless of our size we are aware of our responsibility to offer customers a high octane number product consistent with the demands of today's high compression automobiles. Our search for a process to give us a high quality product plus low initial and operating costs led us to the Platforming process. In 1955 we placed on stream a 750 B/SD Platforming unit. To prepare the feed for the Platforming unit a 1000 B/SD Unifining unit was also installed.

Walter Famariss, Jr.

Famariss Raises Octane Number

With the addition of these units we were able to increase the octane number of our straight run gasoline from 68 RON to 97-98 RON giving our customers a quality product meeting the highest standards in our area. These new units enabled us to boost our total refinery throughput to 2,250 B/SD. Presently we are planning to expand our capacity 50 percent. Catalytic Cracking and additional Unifining facilities are processes being considered. The additional Unifining unit will be used for the treating of intermediates permitting us to enter new markets, thus substantially increasing the value of these products.

Growth Necessitates New Facilities

Perhaps you would be interested in our early growth and problems prior to the installation of the Platforming-Unifining units. Famariss Oil and Refining Company was formed in 1947 as an outlet for the marketing of a small amount of crude I was handling in this area. In 1949 we leased a small refinery at Monument, New Mexico, and in August we started operation of the refinery processing 450 barrels of oil per stream day. Market demands quickly exceeded this production. We therefore gradually increased production to the refinery's apparent maximum limit of 750 B/SD.

During this period all of our production was sold to other refineries for further processing. In 1951 we completed facilities for adding tetraethyl lead and the consequent tankage to enable our refinery to manufacture finished gasoline. We were then able to sell our motor fuel locally. So successful was our operation that in 1952 we purchased the Monument refinery from the leasor. We dismantled the refinery and moved the various structures and equipment one-half mile to a new location on our property. In just 90 days we were once again in production; this time throughput was increased to 1,200 B/SD.

UOP Aids In Solution Of Process Problems

But soon again we faced the problem of increasing production to meet the rising demands of our marketing area—an area which includes all of New Mexico, West Texas and the eastern portion of Arizona. Yes, demand for our motor fuel was increasing but so were compression ratios of automobiles requiring a higher and higher octane number gasoline. This can be an excessively costly problem for a small refiner. In this regard we met with engineers of Universal Oil Products Company, licensor of petroleum refining processes. UOP analyzed our needs in view of our economic and financial framework and suggested the Platforming unit—with a Unifining unit to prepare the feed stock for more efficient processing in the Platformer. We are happy to report that this was an ideal solution. Originally designed for research octane number production of 93.5 we were able to produce a gasoline of 97-98 research octane number by increasing the severity rate somewhat, yet allowing for further octane number increases if desired.

In Operation

The charge to the combination Platforming-Unifining unit—60% locally produced condensate and 40% straight-run gasoline—is prefractionated to produce a 150-400° F., 56° API heart cut. This is the liquid portion of the feed to Unifining. Excess hydrogen (from Platforming) joins this stream, is preheated, brought to reaction temperature in a fired heater, then enters the reactor and subsequently, a high pressure separator. Here any excess hydrogen is vented to the fuel gas system. The liquid product goes to a low pressure separator and thence to a stripper where the H_2S is removed overhead. The bottom product is the Platformer charge.

Our company is marketing three grades of gasoline—premium, regular and government grade. Bottoms from the prefractionator are being marketed as sand fracturing oil, which is finding increasing usage in revitalizing low producing oil wells.

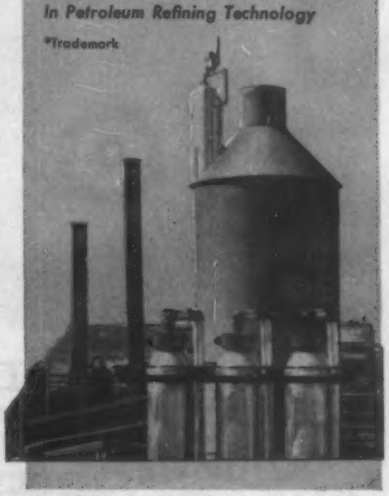
Here at Famariss Oil and Refining Company we are looking into the future confident that whatever the motor fuel requirements of our customers may be we will continue to produce products meeting the highest competitive standards.

Octane number of straight run gasoline increased nearly 50% for Famariss with UOP Platforming® and UOP Unifining* processes

designed, engineered and licensed by
UNIVERSAL OIL PRODUCTS COMPANY
UOP
© 30 ALGONQUIN ROAD
DES PLAINES, ILL., U.S.A.

More Than Forty Years Of Leadership In Petroleum Refining Technology

*Trademark



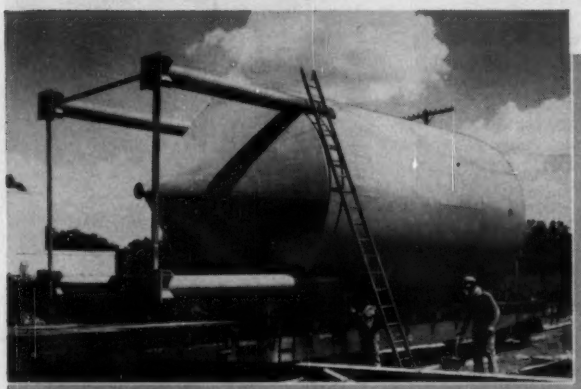
(Adv.)

In Custom Fabrication of

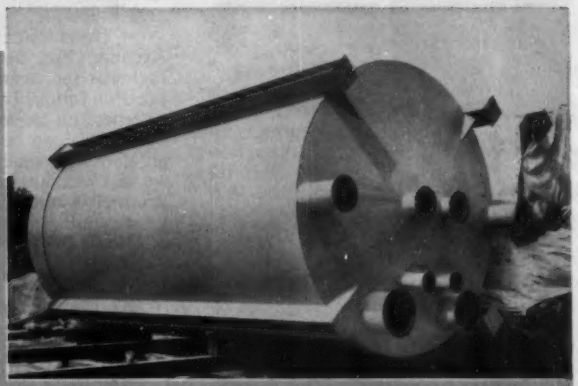
CODE TANKS and PRESSURE VESSELS

there is no substitute for *Experience*

Modern Welding offers a wealth of experience in custom fabrication. Our well equipped strategically located plants serve chemical processing and petroleum industries throughout the world. Our facilities are at the disposal of the men who design, construct, operate and maintain processing plants.



Sludge Settler tank for petrochemical plant is the first in this revolutionary new design.



Dual purpose phenolic-lined polyethylene storage tank with structural reinforcements.

Calibration and prover tank for measuring the accuracy of pipeline crude oil meters.

Air receiver tanks for compressor stations. Pressure tested in 450 lbs. of hydrostatic pressure conforming to A.S.M.E. 1952-A code. Each X-ray tested.

MODERN TANKS QUALITY

MODERN WELDING COMPANY

INCORPORATED

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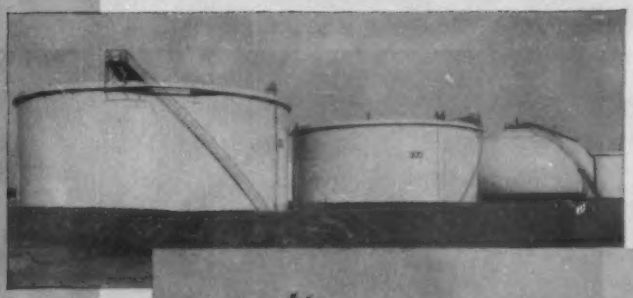
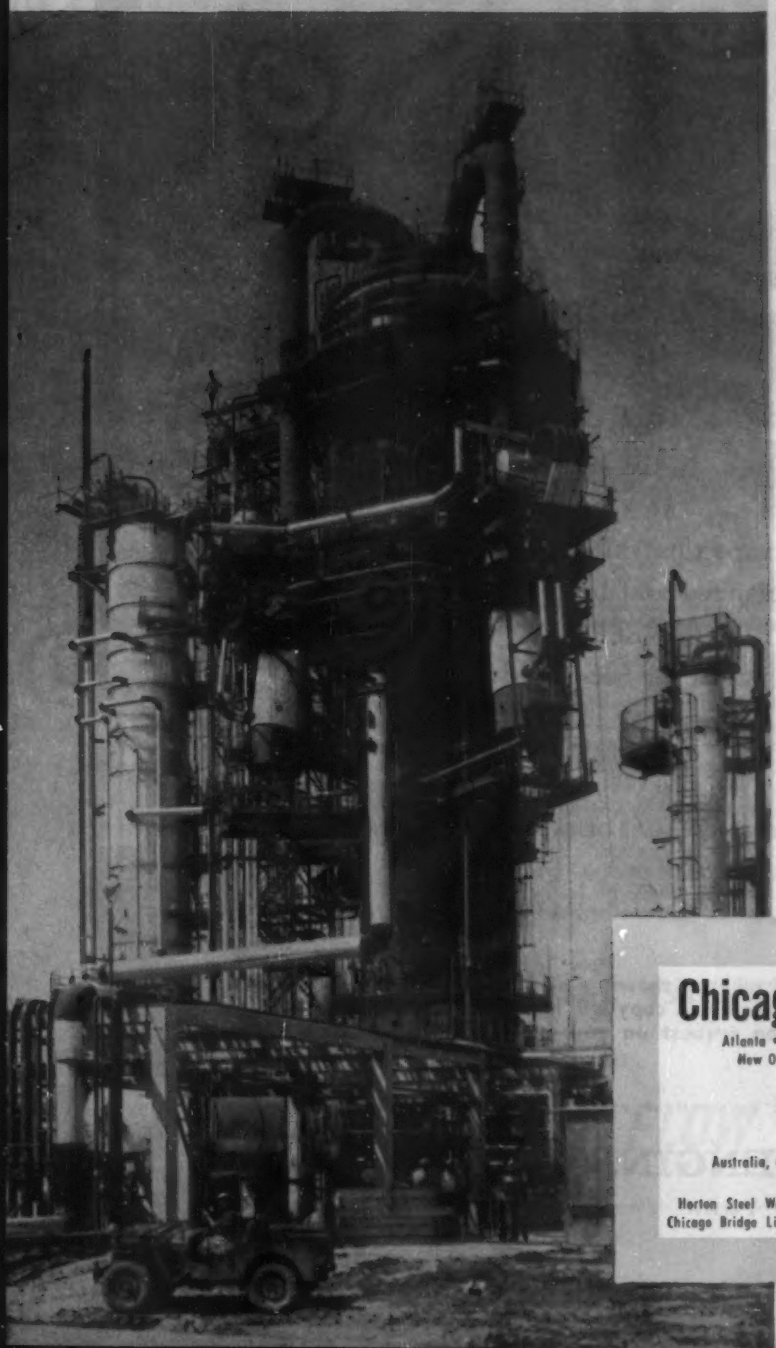
77

CB&I **Structures serve as WORKING PARTNERS for American Oil Company Refinery**





Where there are refining operations there are sure to be welded steel storage and processing structures built by CB&I... *Working Partners* built to exacting specifications because they are backed by the expert and *coordinated* design, engineering, fabrication and erection services that are available from CB&I.

At American Oil Company's 35,000,000-bbl. per day Yorktown, Virginia, refinery 77 CB&I-fabricated structures play an important role. Reactor, regenerator, crude, vacuum and absorber towers and catalyst hoppers are teamed with 62 Horton storage tanks, Hortonspheres® and Hortonspheroids® to serve many phases of this modern, efficient refinery operation.

Yes, where there's refining—you'll find the experienced *craftsmanship in steel* that is CB&I. A new booklet describes CB&I FIELD SERVICES. Write our nearest office for a copy.

Top: Horton Pontoon Floating-Roof tanks, Hortonspheroids and Hortonspheres at Yorktown refinery.

Left: American Oil Company's modern orthoflow converter makes extensive use of CB&I-fabricated components. Equipment was furnished through M. W. Kellogg Company.

P60CB(R)

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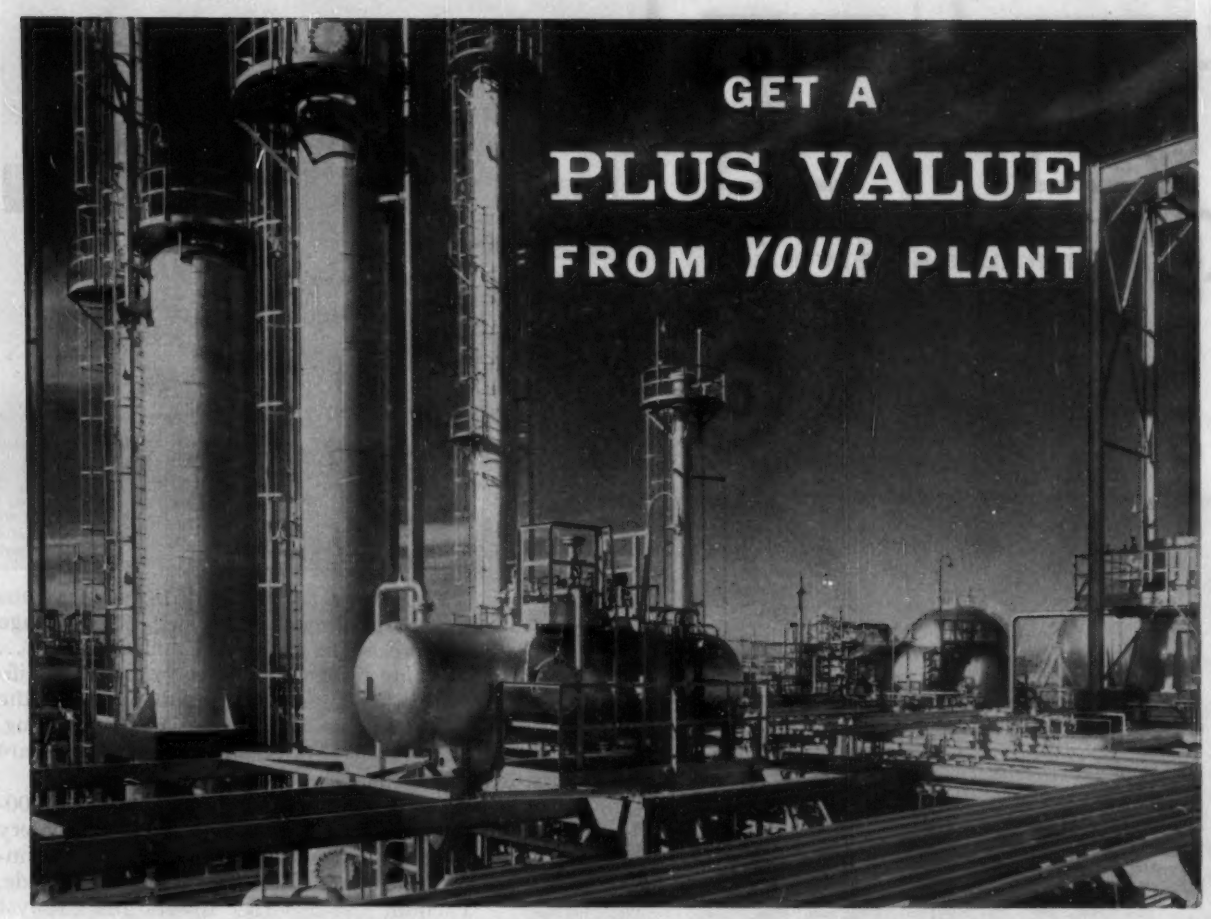


You always get a *plus value* in engineering ability and construction skill when your plant is planned and built by The REFINERY ENGINEERING Company. TRECO has never been guided by *minimum* requirements on any job, large or small.

Remember the *plus value* TRECO offers when you plan your next plant.

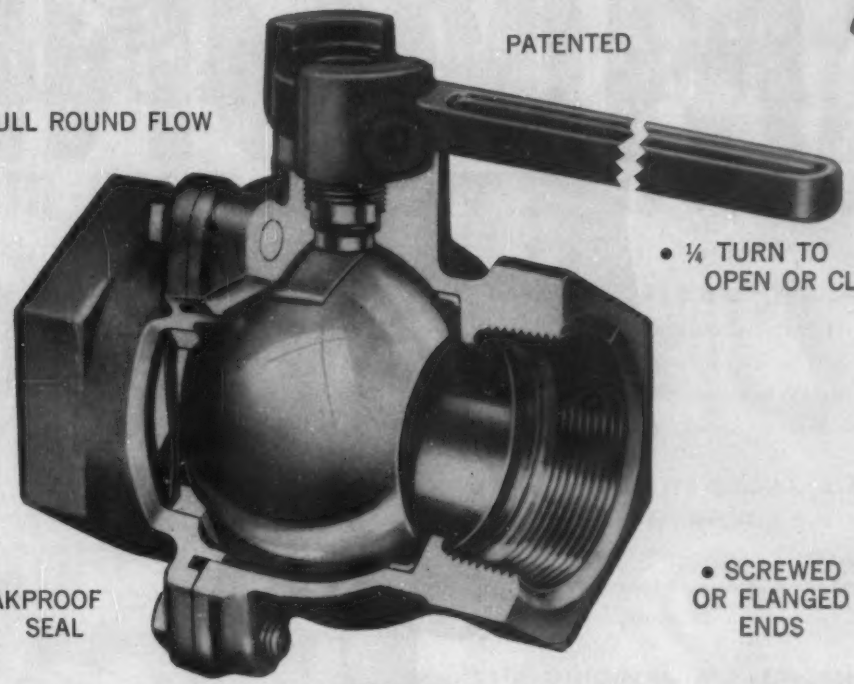
A brochure showing work done by TRECO is available. A copy will be mailed you promptly upon request on your company's letterhead.

TRECO

A DIVISION of VITRO CORPORATION of AMERICA

The REFINERY ENGINEERING Company

NEW YORK TULSA TORONTO



Who sends Valentines to a Rockwood Ball Valve?

Rockwood Ball Valves are operating, without leakage, in plants throughout the country, and the pleased comments we receive read like valentines:

A brewing company has opened and shut their Rockwood Ball Valves over two million times — and their valves are still going strong!

An oil company was surprised (although we don't know why — it's a common occurrence) when Rockwood Ball Valves stopped leakage other valves could not stop.

A company boiling starch found Rockwood Ball Valves lasted longer than any other valve previously used.

A tannery tells us Rockwood Ball Valves are the quickest, easiest valves to open and close.

Frankly, we can't blush — it would be false modesty. Rockwood Ball Valves are perfect for many jobs — we build them that way. They come in all pipe sizes, rated at 300 W.O.G. Tell us where to send it — and we'll give you a booklet with complete information. Valves are tested and listed by Underwriters' Laboratories, Inc. Distributors in principal industrial areas.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
2230 Harlow Street
Worcester 5, Mass.

Please send me your illustrated Rockwood Full, Round Flow Ball Valve folder.

Name.....

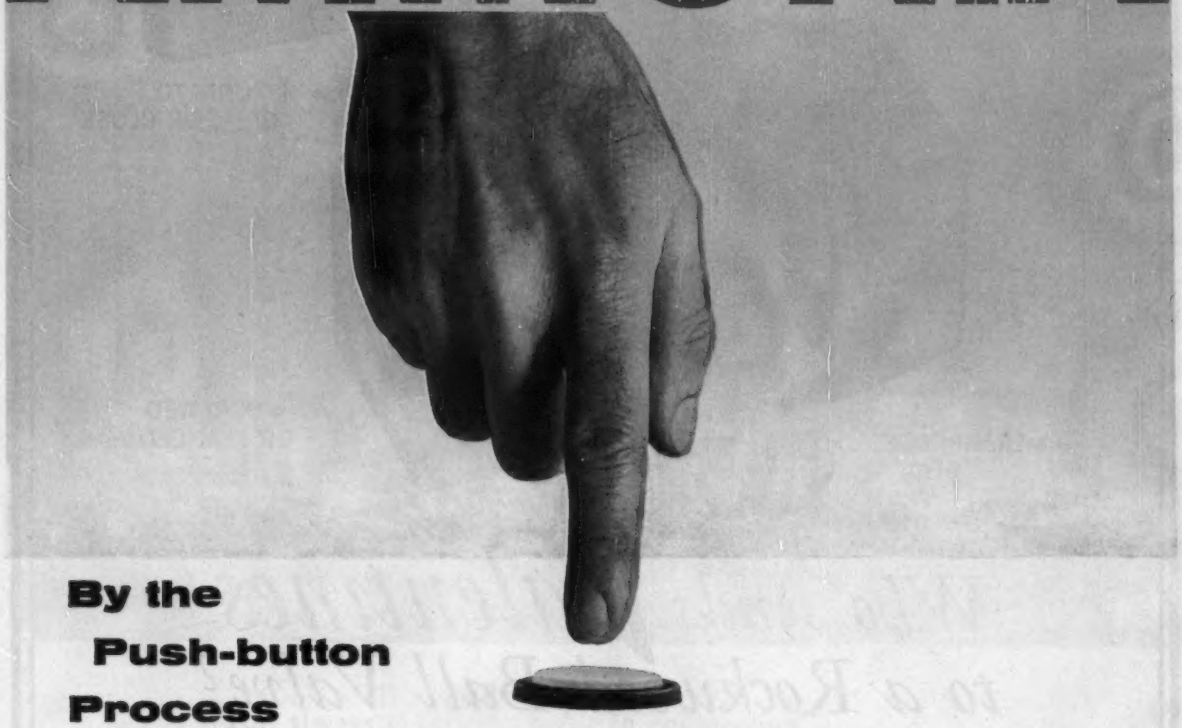
Title.....

Company.....

Street.....

City.....*Zone*...*State*.....

AMMONIA



By the Push-button Process

Ammonia plant start-up operations are virtually a matter of "push-button" routine with Chemico; for Chemico has designed and constructed more than 50 ammonia plants in the last 40 years.

While new-comers to the field are constantly running into costly difficulties and delays with unreliable and even untried processes, Chemico designed plants are profitably producing an estimated 25% of the world's synthetic ammonia. Investors in the chemical industries may be interested to learn that despite the proven performance and countless advantages of Chemico's ammonia processes, it frequently costs less to build a Chemico Plant.

Write today for Chemico Bulletin #357 which lists the alternate feed stocks and methods for gas purification and production in the making of ammonia. .

CHEMICO

CHEMICAL CONSTRUCTION CORPORATION
525 West 43rd Street, New York 36, New York

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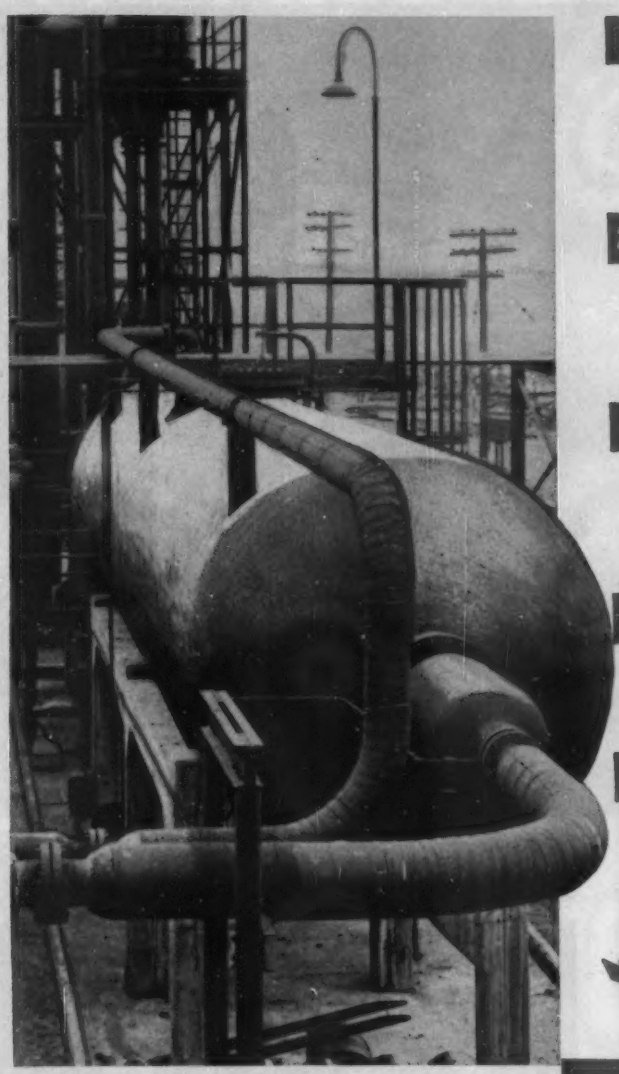
For more data on advertised products, use Readers' Service Cards, last page.

5 REASONS WHY
TRETOLITE all-chemical DESALTERS
are in use wherever oil is refined



1 **95 to 100% SALT REMOVAL**—The highest standards of purification possible in commercial operation. In addition to a 95 to 100% range salt removal, Tretolite Desalters also remove other solids, fines and trace metals from the crude charge.

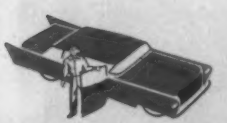
2 **AVERAGE CHEMICAL COST OF $.0013 PER BARREL**—A real economy of operation that is consistent . . . about 1.3 mills per barrel. Water usage is also minimal, and only the pumps require power.

3 **THE ORIGINAL ALL-CHEMICAL DESALTING PROCESS**—Tretolite originated all-chemical desalting, and was the *first organization* to provide a desalting system for refiners. The result is a desalting experience unequalled in this field.

4 **PERFORMANCE-PROVED EVERY DAY BY 1½ MILLION BARRELS**—Wherever you see refining, you're sure to see Tretolite Desalters.

5 **AUTOMATIC OPERATION**—The epitome of simplicity—requires only minimum operating attention. If you have a desalting problem . . .

Ask the Man in the Red Car



The Tretolite Service Engineer is always on call to assist you in any of your maintenance and processing problems.

Chemicals and Services for the Petroleum Industry

DESALTING • CORROSION INHIBITING • DEMULSIFICATION
SCALE PREVENTION • WATER DE-OILING • METAL DEACTIVATION • ADDITIVES

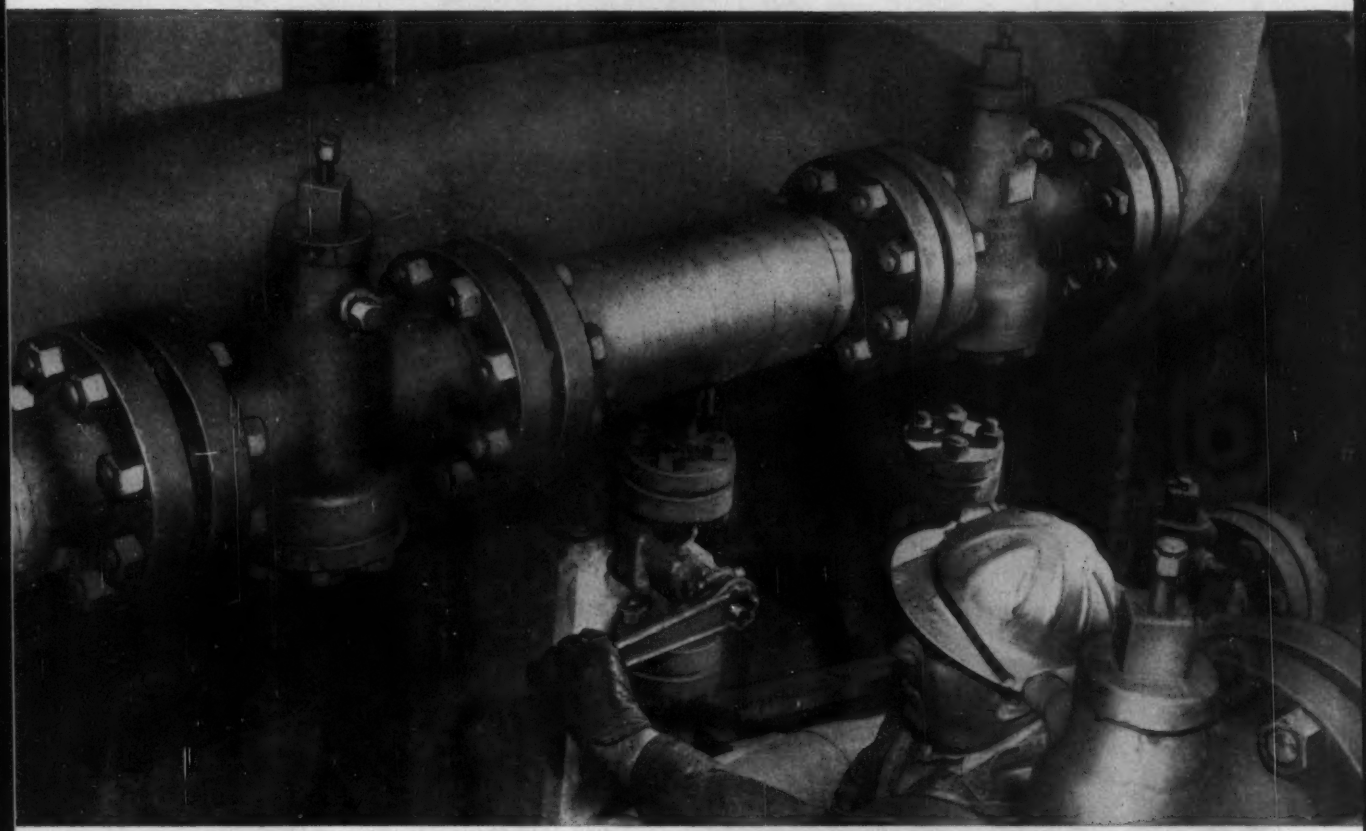
TD-58-2

TRETOLITE COMPANY
DIVISIONS OF PETROLITE CORPORATION
369 Marshall Avenue, St. Louis 19, Mo
5515 Telegraph Road, Los Angeles 22, Calif.

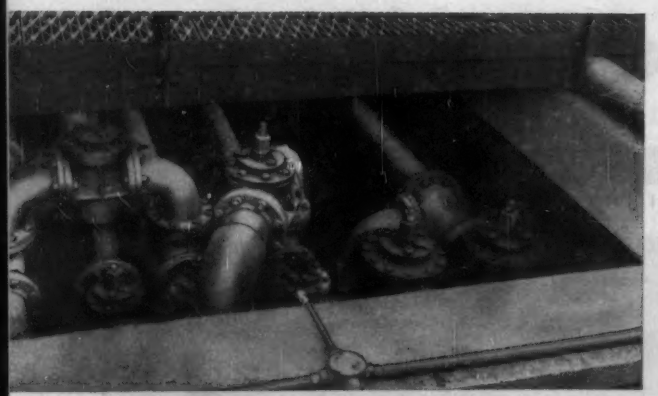
For more data on advertised products, use Readers' Service Cards, last page.

Where There's No

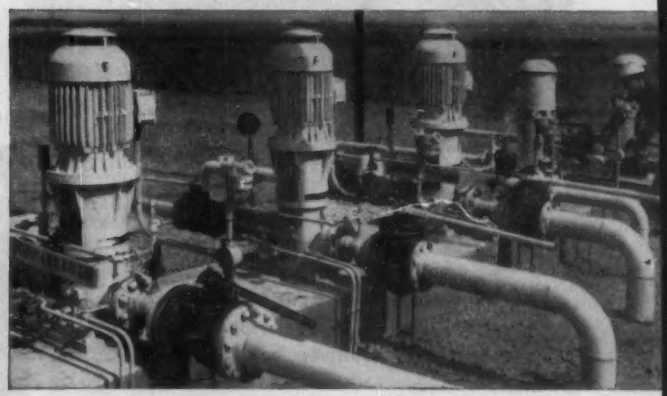
ROCKWELL-Nordstrom



Rockwell-Nordstrom lubricant sealed valves *stay* leakproof in polymerization plant service.



For refinery transfer lines, Rockwell-Nordstrom valves close with fast, easy, quarter-turn operation.



At gasoline plants, Rockwell-Nordstrom valves can't be matched for safety on light hydrocarbon services.

Time For Down-Time

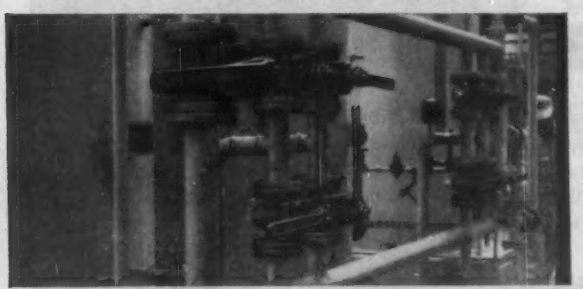
VALVES Perform Better, Longer, For Less Money

One good way to cut costly down-time in "round-the-clock" process units like refineries and gasoline plants is to use Rockwell-Nordstrom valves. That's why so many oil and gas companies standardize on Rockwell-Nordstrom valves where flow control *must* stay dependable and safe month after month.

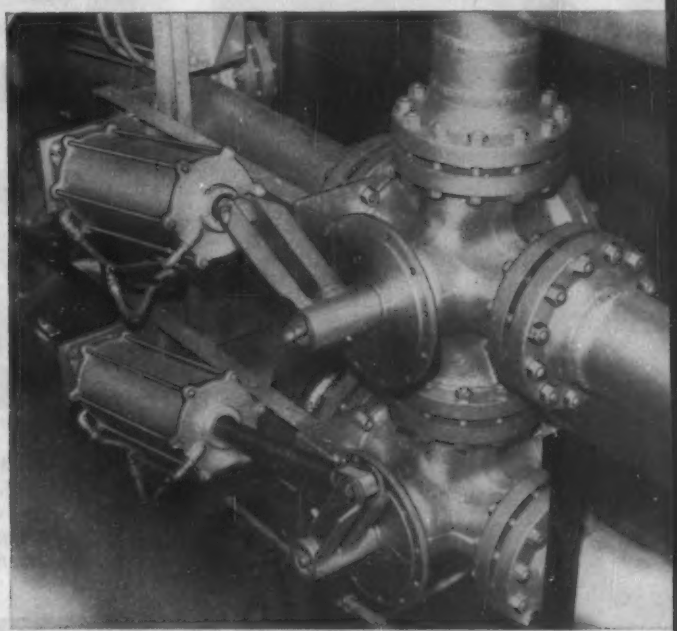
The reason for the greater dependability and safety of Rockwell-Nordstrom valves is *pressurized lubricant.* This forms a leakproof seal for tightest shut-off and jacks the plug for fast, easy quarter-turn operation. Lubricant also cuts maintenance costs and adds years to valve life by eliminating grinding metal-to-metal wear.

The original and world's most complete line, Rockwell-Nordstrom lubricated plug valves cost no more to buy—and far less to use—than any other valve. Available in WOG ratings to 10,000 lb. and sizes to 30 x 34" in steel, stainless, semi-steel and corrosion resisting metals. Write for more details: Rockwell Manufacturing Company, Pittsburgh 8, Pa. *Canadian Valve Licensee:* Peacock Brothers Limited.

Rockwell-Nordstrom valves on cooling tower water lines operate two to five times faster than ordinary valves.



Rugged design and unexposed seating in Rockwell-Nordstrom valves prevent pump shock load wear on glycol circulation service.



These air operated 4-way Rockwell-Nordstrom Multiport valves on cat reformer stills make control of recycle gas lines fast and dependable

ROCKWELL-Nordstrom VALVES

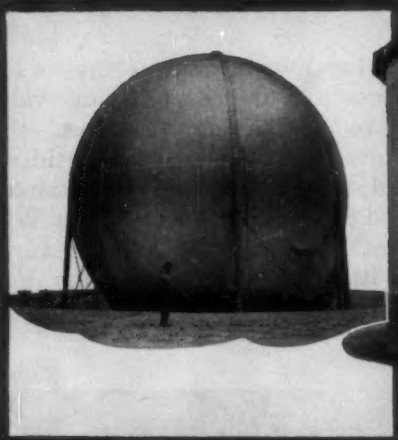
it's ROCKWELL

MANUFACTURING COMPANY

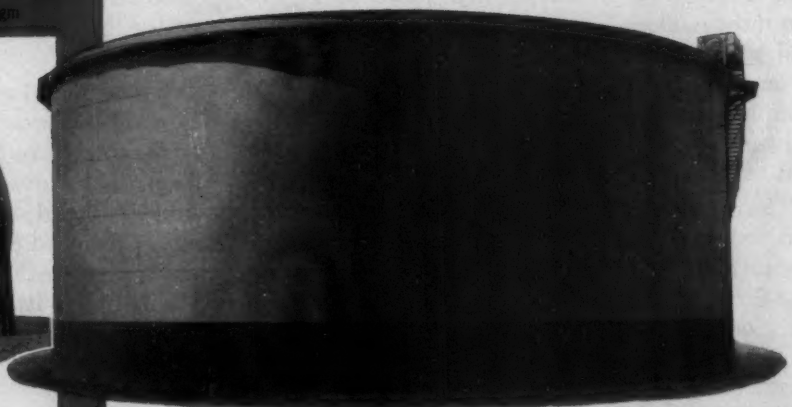
HAMMOND

STORAGE TANKS and PLATE FABRICATION

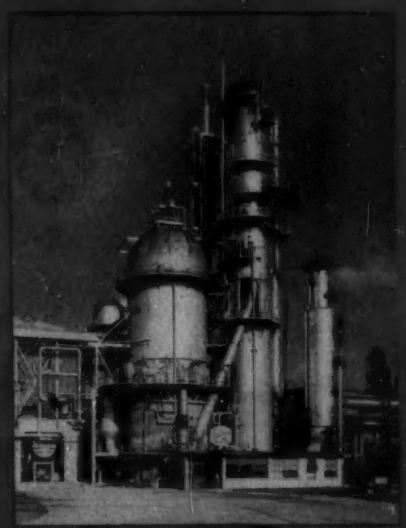
DIALIFT* tank with vapor-saver diaphragm



Hammond Spheres

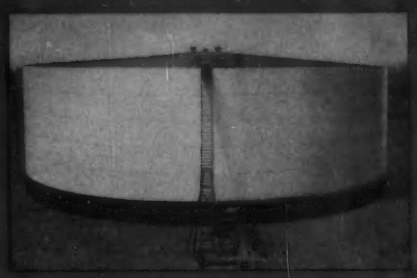


Hammond **TUBESEAL*** and **SPRINGTITE*** Floating Roof Tanks



Process Vessels—Steel • Stainless • Alloys • Cladmetals

Water Storage Tanks



Cone Roof Tanks

The universal acceptance of Hammond-built equipment is the result of more than half a century of experience in the design, fabrication and erection of storage tanks, process vessels and steel plate construction for the petroleum, chemical and allied industries, and for water supply.

HAMMOND IRON WORKS

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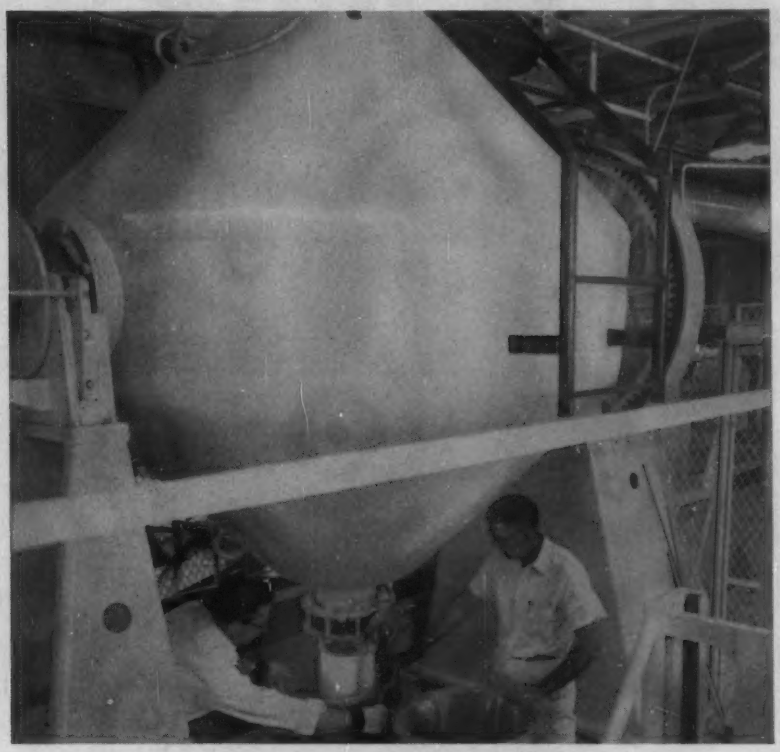
HAMONDTANK

Corrosioneering News

Quick facts about the services and equipment available to help you reduce corrosion and processing costs.

Published by The Pfaudler Co., a division of Pfaudler Permutit Inc., Rochester, N.Y., U.S.A.



Now Upjohn saves 32 hours drying 2500 pounds of Orinase

Sixteen hours are all it takes for the Upjohn Company to dry and blend 2500 pounds of Orinase in the Pfaudler conical dryer-blender.

It used to take forty-eight hours to dry that much of Upjohn's oral antidiabetic in two straight vacuum dryers.

Upjohn says it also saves eight hours a week in materials handling time with the new dryer.

Since it's a pharmaceutical, the product poses a purity problem which is nullified by the noncontaminating glassed-steel construction of Pfaudler dryer-blenders.

Other companies, many handling corrosives, report similar savings, some of them cutting drying time by as much as 90%. The smooth glassed surfaces of the drying chamber are insensitive to all corrosives except hydrofluoric acid and hot alkalies above pH12.

The Pfaudler design offers a solid, one-piece drying chamber which offers maximum strength and drying area unbroken by joints or clamps. The vacuum exhaust tube is centrally located for the most efficient vapor removal.

There's much more about the Pfaudler dryer-blender that proves its efficiency of operation over other designs . . . all of it in Data Sheet 26 which you'll find offered in the coupon.

Corrosion resistance of glassed steel unimpaired by gamma radiation

No adverse effects could be detected from the exposure of Pfaudler glassed steel to 10^{10} roentgen of gamma radiation. Tests were recently completed by Pfaudler in cooperation with Oak Ridge National Laboratory and other installations.

Glassed steel is being considered for chemical processing involving nuclear energy wherever corrosive conditions are particularly severe and ease of decontamination is important.

Probable uses of glassed steel in this field include storage of acids and other materials which may or may not be radioactive, storage and disposal of radioactive wastes, and chemical processing of highly radioactive and corrosive materials.

A larger test program is now under way to follow up the preliminary results and to determine even more conclusively the effect of radiation on glassed metals.

"Is Pfaudler making Sputniks?"—This was an oft heard question recently from visitors to our Rochester plant. What they saw was this unusual new cone bottom reactor we fabricated and glassed for a leading chemical producer. All those nozzle openings on the conical surface made glassing a little "touchy," so it took us a little longer than with standard models. The vessel is 388 inches long with a 138-inch OD, and will be used for storing and purging polymer chips at 160°F. An internal column does the purging with an inert gas.

Why do we show it here? To suggest that we can put the corrosion resistance of Pfaudler glass to work on more than conventional reactors, storage tanks, columns, etc.

THE PFAUDLER CO.
a division of PFAUDLER PERMUTIT INC.
Dept. PR-28 Rochester 3, N.Y.

Please send information on: ☐ Conical Dryer-Blenders ☐ Pfaudler Buyer's Guide.

Name.....

Title.....

Company.....

Address.....

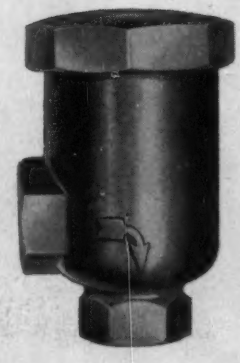
City.....Zone.....State.....

For more data on advertised products, use Readers' Service Cards, last page.

need steam traps?

name the way you want them!

TYPE A



TYPE D

TYPE C

Nicholson can supply your steam traps, exactly as you want them . . . for any service, any condition. Name the size, material, pressure, capacity you need. Types A, D, C are the ones you'll most likely use. Make your selection.

Sizes: A—from ¼" to 1". D—from ¼" to ¾". C—from ½" to 2".

Materials: Cast Iron and Cast Steel.

Pressures: A and D—Vacuum to 200 lbs. C—Vacuum to 300 lbs.

Capacities: From two to six times greater orifice area and capacity than other traps of comparable size.

Why wonder about your steam traps . . . when you can get Nicholsons exactly as you need them for your own applications. Nicholson traps are simple in design, have only one moving part . . . a valve that discharges condensate and prevents steam loss.

You get faster warmup, with high air-venting capacity. You eliminate costly leakage, with a powerful shut-tight valve action. You get a trap that's service-tested, when you specify Nicholson. You can try one . . . without obligation! W. H. Nicholson and Company, 12 Oregon St., Wilkes-Barre, Pa. Sales and engineering offices in 98 principal cities.

NICHOLSON

of Wilkes-Barre

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Claymont's 160-inch plate mill in action. Fully integrated steel producing facilities and a complete range of fabricating equipment make Claymont a reliable source of quality steel plate and plate products for industry.

Photo by d'Arazien

CLAYMONT STEEL PLATES

CF&I

CHECK CLAYMONT FOR—Alloy Steel Plates • Carbon Steel Plates • Stainless-Clad Steel Plates High Strength Low Alloy Steel Plates • CF&I Lectro-Clad Nickel Plated Steel Plates • Pressed and Spun Steel Heads • Manhole Fittings and Covers • Fabricated Steel Products Large Diameter Welded Steel Pipe

PRODUCTS OF WICKWIRE SPENCER STEEL DIVISION • THE COLORADO FUEL AND IRON CORPORATION

Plant at Claymont, Delaware • Sales Offices in all Key Cities

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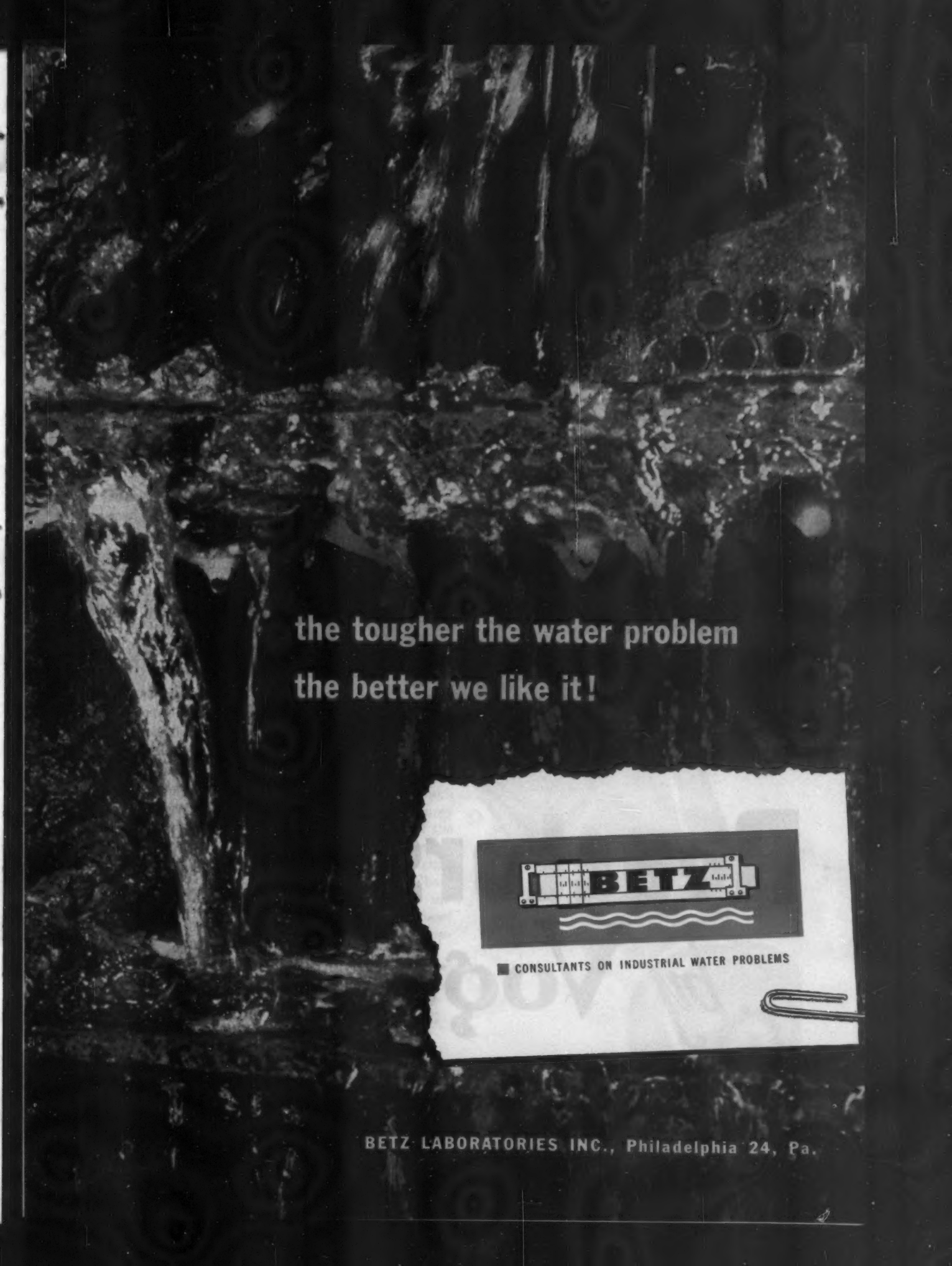
GUARDING 5 BILLION FLIGHT MILES

"On final approach," radios the pilot. Down goes the landing gear for another happy landing. Special petroleum lubricants and fuels – pioneered by Texaco research – play an important part in the 5 billion passenger miles flown each year. *During the past 22 years more scheduled revenue airline miles in the United States have been flown with Texaco Aircraft Engine Oil than with all other brands combined.* A typical example of how Texaco research cooperates with industry.

TEXACO

THE TEXAS COMPANY

Progress . . . at your service


the tougher the water problem
the better we like it!
BETZ
CONSULTANTS ON INDUSTRIAL WATER PROBLEMS
BETZ LABORATORIES INC., Philadelphia 24, Pa.

KING SIZE

This giant 37 ton Cat Poly Reactor is one of 4 units shipped to a large petroleum refinery in the State of Washington. It is 4'-3½" in diameter by 32'-0" long and has a 1 3/16" thick shell. Each of its 8" thick heads is attached to the shell channel with 28 special alloy stud bolts 2¾" diameter by 15¼" long having nuts 4¼" across the flats. Into the 5¾" thick tube sheets 190 tubes, 2½" O. D., No. 5 gauge and 30'-0" long, are rolled and seal welded. Designed for 1,230 lbs. pressure on the tube side, the reactor was completely X-rayed and stress relieved.

Vogt, a leading builder of shell and tube reactors for poly plants, has the competently skilled personnel and modern mechanical facilities with which to provide heat transfer equipment for the most exacting services in petroleum refineries, chemical plants, and related industries.

Reactors ...by Vogt

A bulletin describing the wide range of heat transfer equipment built by Vogt is available upon request.

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HENRY VOGT MACHINE CO., LOUISVILLE, KENTUCKY

BRANCH OFFICES: NEW YORK, CHICAGO, CLEVELAND, DALLAS, PHILADELPHIA, ST. LOUIS, CHARLESTON, W. VA.

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No question about it... **CHASE®**

HEAT EXCHANGER TUBES

lower operating costs!

How? By providing peak operating efficiency through many *more* years of service! It's that simple. But not simply arrived at. It takes precise alloying – the addition of the right amount of antimony to *resist* dezincification! It takes severe field and laboratory testing! It takes rigid quality controls! Yes – all this and more to keep Chase Antimonial Admiralty Heat Exchanger Tubes the unquestioned leader. It will pay you to learn about Chase! Write today for your free 54-page manual: *"Chase Condenser and Heat Exchanger Tubes."*

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SUBSIDIARY OF KENNECOTT COPPER CORPORATION

The Nation's Headquarters for Brass, Copper and Stainless Steel

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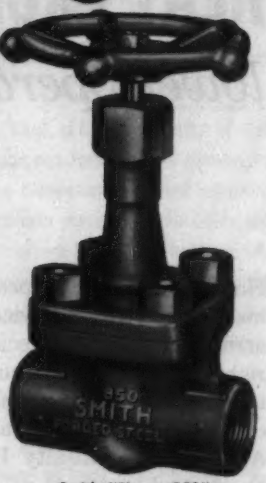
"Riding HIGH on the Hog"...

Today, SMITH Forged Steel Valves are used and approved by a large portion of the major Refineries, Chemical and Petrochemical plants in this country and Canada. Performance reports from these plants clearly prove that the extra stamina and strength built into all SMITH Valves — the ability to give longer, trouble-free life in service — result in substantial savings per valve. Relatively small though savings per unit may be, they nevertheless represent accumulated savings of major proportions when multiplied by the thousands of SMITH Valves now in operation.

To our customers, operational savings mean profits. To us, they mean an ever-increasing volume of day-to-day repeat orders. That's why we're *all* "riding high on the hog."



Smith "Figure 850"
Inside Screw Valve
Sizes: ¼"-2" incl.

Write today for our new catalog giving complete information on our entire valve line.

NEW ENGLAND VALVE Corporation

P. O. BOX 1047 · WORCESTER, MASSACHUSETTS

West Coast Distributors: BETHLEHEM SUPPLY CO., LOS ANGELES, CALIFORNIA

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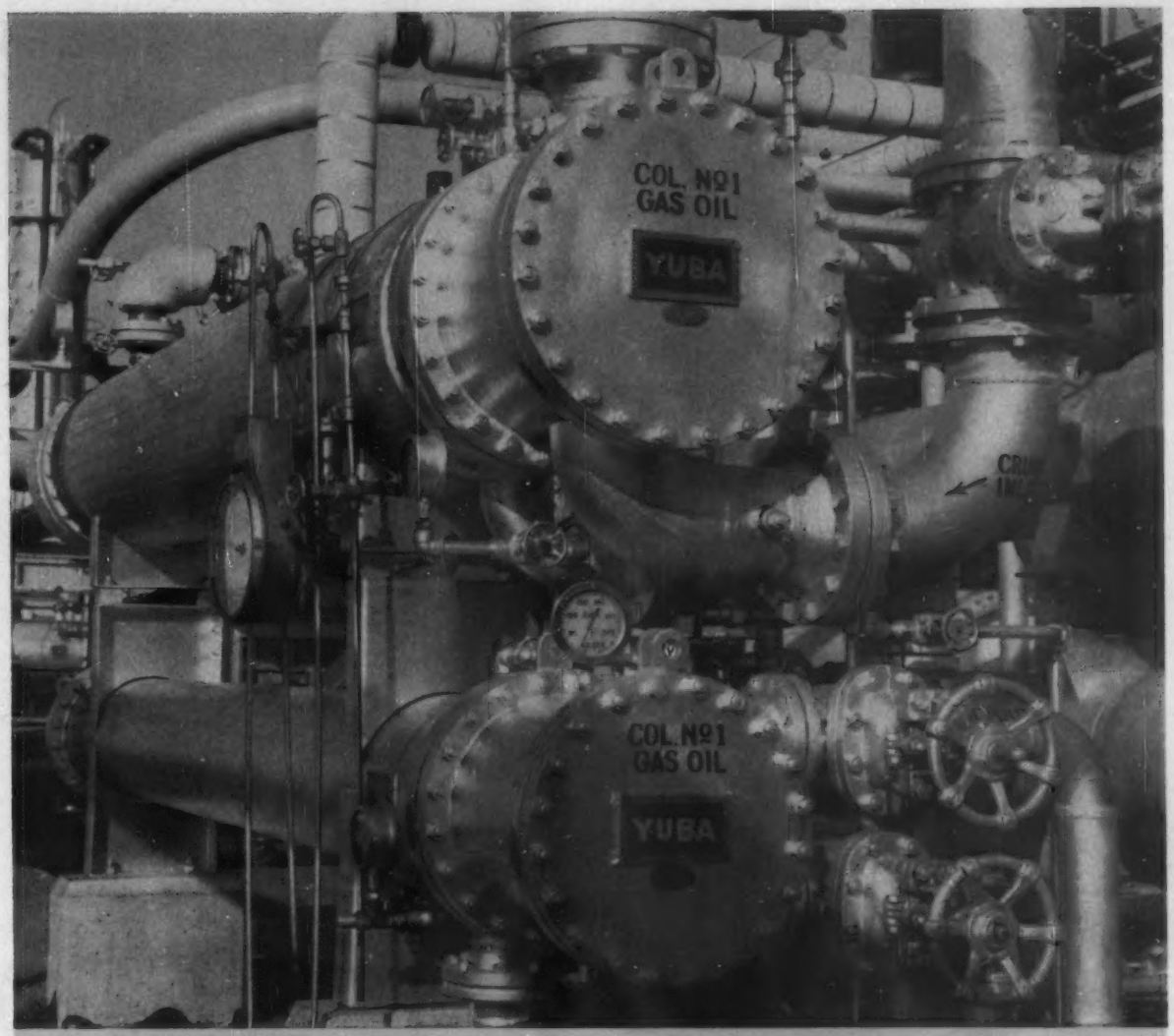

WHAT YUBA MEANS BY ENGINEERED HEAT EXCHANGERS

The reputation of a manufacturer of heat exchangers is based on the sales engineer who services your account . . . the design engineer who designs the equipment and selects the materials . . . the welding engineer who specifies the welding procedures . . . the quality control engineer who sees that incoming materials meet specifications . . . that top-quality work is performed at every stage of manufacture . . . and the production control engineer who schedules your order so it will arrive the day you need it.

These competent people are to be found at Yuba's plants in both the East and the West. Yuba offers creative engineering and precision manufacturing—send us your inquiry.

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economical to install
chemically resistant
simplified tube take-offs
the great new flat multiple-tube instrument line harness
DEKORON
"M" RIBBON
"P" RIBBON
Dekoron "M" Ribbon or "P" Ribbon makes instrument tubing costs plummet. That's because the chemical resistance of the plastic sheath even outlasts expensive alloy tubing . . . because you get all the advantages of bundle installation in a flat, easy-to-handle "ribbon" . . . because the perforated plastic "webs" between individual tubes enable tubes to be stripped back singly or in groups without tools and without destroying protective coating. So tube up with Dekoron "M" Ribbon or Dekoron "P" Ribbon —it's a "pipe" to install.
AA-5489
Dekoron "M" Ribbon consists of 10 individual copper or aluminum tubes with vinyl plastic coating; Dekoron "P" Ribbon is 10 polyethylene "P" tubes with vinyl sheath.
Dekoron products
QUALITY • RESEARCH • SERVICE
SAMUEL MOORE & CO. • DEKORON PRODUCTS DIVISION • MANTUA, OHIO

A large perforated deck for a Gulf Coast Refinery.

"custom made" to cut cracking costs!

Hendrick perforated column internals are tailored to your detailed specifications. Then they are fabricated from Hendrick's stock of commercially rolled metals in gauges selected by your own process designer.

Whether your column internal assemblies require perfectly round, square or slotted perforations, you can be sure Hendrick will meet every requirement with clean cut perforations that assure uniformity of mesh and long service life.

The result—you get greater fractionating tower capacity (up to 20% over trays of non-perforated design) and substantially reduced cleaning, replacements and downtime costs. Unit costs may be appreciably lower than non-perforated. Mail coupon for literature.

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Name_____Title_____

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A Reactor That Won't React — To Corrosion!

Designed for 300 psig at 450F, this reactor will be subjected to unusually corrosive service. Hastelloy, a non-ferrous nickel-base alloy, was specified to line the vessel. The ASME Code shell was first lined with narrow strips and segments by manual metallic-arc welding. Then the welds were covered by cap strips, heliarc-welded to the liner. Multiple tests confirmed the excellence of the welds. Manually welding so many feet of alloy called for the most skilled craftsmanship—the type of craftsmanship Graver has characteristically applied to alloy fabrication for years. When custom-crafted vessels in special alloys are the answer to your corrosion problem, calling in Graver assures quality fabrication, long life and dependable service.

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ALLOY DIVISION

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IN PETROLEUM ... from wells to wings!

BASIC CHEMICALS ... from GENERAL CHEMICAL

At practically every stage of petroleum production and processing, you will find need for basic chemicals from General Chemical . . . a supplier you can count on for prompt delivery of these key process materials, that meet your exact requirements:

ALKYLATION
Anhydrous Hydrofluoric Acid
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POLYMERIZATION
Fluosulfonic Acid $HO:SO_2F$
Boron Trifluoride
Sulfuric Acid

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Sulfuric Acid
Sulfan® (Stabilized Sulfuric Anhydride)
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Hydrochloric (Muriatic) Acid

DETERGENTS, CLEANERS & BUILDERS
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Hydrofluoric Acid
Sodium Bifluoride

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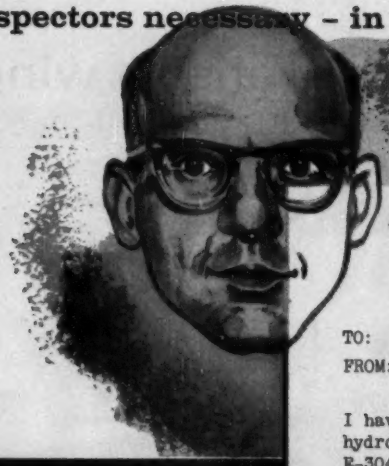
Basic Chemicals for American Industry

Are customer-inspectors necessary – in heat exchanger fabrication?



APEX PETRO-CHEM CORP.
INSPECTOR'S REPORT

TO: Chief Inspector
FROM: Southwest Regional Inspector

I have just witnessed the final hydro tests on Items E-301, E-302, E-304 and E-305, and have approved them for immediate shipment. Western maintained its usual high quality.

Delivery is being made, incidentally, one week ahead of schedule.

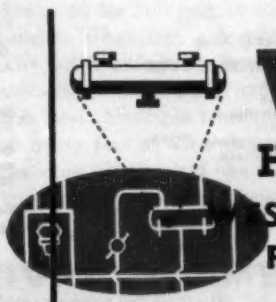
Question: Since heat exchangers fabricated in high standard shops are carefully inspected in accordance with A.S.M.E. Boiler and Pressure Vessel Code, as well as by the manufacturer himself, is it necessary for the customer to spend his own time and money in duplicating this work?

Answer: No, it is not necessary. However, we recognize that all first-line engineering and operating companies are going to make inspections as a matter of policy, THEREFORE . . .

. . . in the case of WESTERN, customer-inspectors are *welcome,* because it is from their reports and discussions that Western has acquired a reputation for the production of high quality heat transfer equipment throughout the petroleum and chemical industries.

Customer-inspectors, in other words, are Western's best salesmen.

Western's "open-door" policy to *all* customer-inspectors is worth investigating.



WESTERN
HEAT EXCHANGERS
STERN SUPPLY COMPANY
P.O. Box 1888 – Tulsa, Oklahoma

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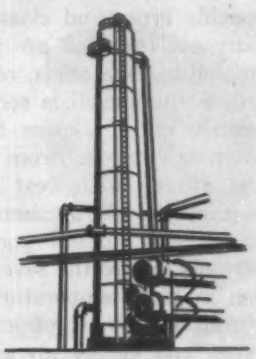
OAKITE *Maintenance* CLEANING

helps maintenance crews save time, cut costs, keep equipment operating efficiently

Specialized Oakite cleaning, descaling and related materials plus Oakite up-to-date methods are widely used in all branches of the petroleum processing industries. These specialized materials and methods . . . developed through more than 45 years of experience . . . are designed to provide you with the best in all round cleaning efficiency. What is more—all Oakite materials are backed by a binding guarantee. Your interests are fully protected.

Here are four maintenance jobs, typical of the type of many, Oakite is called upon to do every day of the year. These cleaning operations are fully covered in our free booklet "What Petroleum Men Should Know to Simplify Cleaning". Send for a copy.



1 **TOWER CLEANING.** Oakite lists a wide variety of compounds for removing waxes, resinous products, iron sulfides, oxides and other deposits from bubble caps, trays, downcomers. Circulation method eliminates costly manual cleaning.

2 **HEAT EXCHANGERS.** Oakite offers specialized alkaline and acidic type compounds for removing oil, carbon from shell side; lime scale, rust from tube side. Cleaning is done "in-place".

3 **PAINT STRIPPING.** You can strip paint from storage tank exteriors using your own equipment to apply, recover and recirculate stripper. Oakite provides a complete selection of alkaline and solvent strippers.

4 **SALVAGE.** Oakite has simplified methods to make salvage profitable. They give you a choice of specially compounded materials for cleaning and rust-proofing tools, fittings, valves, chains, pumps, etc.

ON-THE-SPOT SERVICE. Whenever you have a ticklish problem of cleaning to solve you can get quick on-the-spot advice by reaching for your phone and calling your local Oakite Technical Representative. His services are available at all times. For full particulars drop a line to Petroleum Service Division of Oakite Products, Inc., 52E Rector Street, New York 6, New York.

SPECIALIZED INDUSTRIAL CLEANING

OAKITE

MATERIALS • METHODS • SERVICE

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QUALITY REFRACTORIES

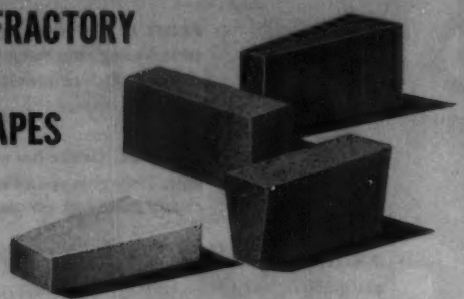
by HARBISON-WALKER serve every petroleum processing need

HARBISON-WALKER products comprise the specific types and classes for each particular purpose. Included are the widely diversified monolithic materials, refractory brick of the entire alumina-silica series and high alumina brands of all classes from 50% to 99+% alumina content. From these can be selected the kinds which best fulfill all the special requirements for maximum corrosion resistance to various sulphur compounds and hydrocarbons and to the severe fluxing effect of oil ash in high temperature furnace operations. Harbison-Walker refractories of the various types and classes are especially adapted for withstanding excessive abrasion and erosion and the disintegrating action of reducing atmospheres through critical temperature ranges.

GUN APPLICATION — For many installations, Harbison-Walker castables are used to best advantage with various types of air placement guns.

TROWELLING—This method is preferred for some applications and the excellent working qualities of Harbison-Walker castables make them easy to use and to secure uniform durable linings.

H-W REFRACTORY BRICK AND SHAPES



Fireclay Brick—All Classes • High Alumina Brick —All Classes from 50% to 99% alumina • DURO and W-ACID, acid-proof brick, floor tile and • DURO tower packing rings and grid tile • Silica Brick • Basic Brick—All Classes

Write Technical Service Department regarding the selection of the refractories best suited for your specific applications.

World's Most Complete Refractories Service

H-W CASTABLE REFRACTORIES and other monoliths

CASTABLES (all classes) · PLASTIC FIRE BRICK (all classes) SPECIAL GUN MIXES · TROWELLING MIXES

These monolith forming refractories are widely used in the petroleum refining and petro-chemical industries. They are available in all the many commercial classes which provide the most desirable combinations of physical and chemical properties for each particular requirement. Among these, several which are most widely used with special benefit in the petroleum industry are briefly described in the following.

HARCAST—Is exceedingly strong and resistant to reducing conditions at operating temperatures and meets rigid specifications used in the petroleum industry. Its composition and low permeability greatly retards corrosion by gases under high pressures. It is used in severe erosion areas such as in regenerator cyclones and catalyst feed lines. The approximate service limit is 2800°F.

H-W 56 LIGHTWEIGHT CASTABLE—Combines light weight with high insulating value and strength to the utmost degree. Produced also with a very low ferric oxide content of less than 0.5%, it provides maximum resistance to reaction with various gases. Among important applications are refinery vessel linings, ducts and breechings, boiler back wall and tube decks, air preheater linings, furnace walls, roofs and doors. The approximate service limit is 2100°F.

H-W EXTRA STRENGTH CASTABLE is exceptionally strong and withstands severe abrasion and erosion at temperatures up to its service limit of 2400°F.

HARCHROME is a special chrome castable which is second to none for abrasion resistance for the range of operating temperatures prevailing in feed lines.

H-W HIGH ALUMINA CASTABLE—Made with crystalline alumina base it is most refractory among castables and due to its extreme purity is especially suited for use in highly reducing atmospheres. Its approximate service limit is 3000°F.

CASTABLE CONSTRUCTION FOR REFINERIES

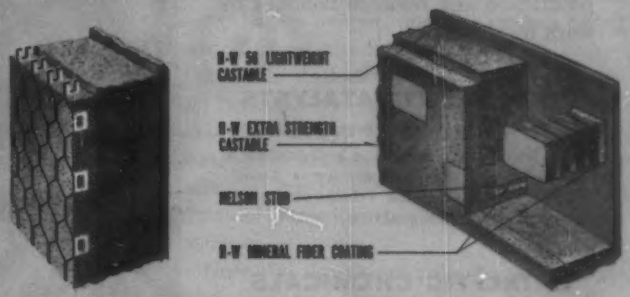


Illustration shows H-W 56 Lightweight (Insulating) Castable next to the regenerator shell with H-W Extra Strength Castable superimposed in hex-steel for working lining.

Typical arrangement of refractory anchor method for monolithic linings in catalytic cracking units. H-W Mineral Fiber Coating provides insulation for metal stud.

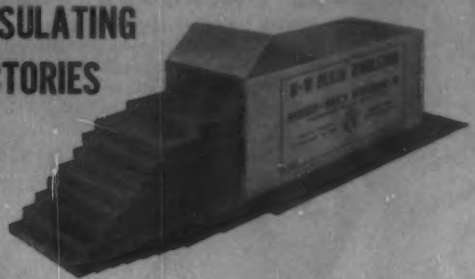
H-W MORTARS

These include a wide variety of both hot and cold-setting cements which fulfill the requirements for laying all the different kinds of refractory brick. Some leading brands are HARWACO BOND, THERMOLITH and KORUNDAL BONDING MORTAR which provide the requirements for laying the alumina-silica and high alumina refractories ranging up to 99% alumina content.

HARWACO MASTIC

This plastic cold-setting monolithic refractory has a working consistency similar to that of stiff putty and is ideally suited for plastering with a trowel, as for example, for sealing V-shaped spaces at the exterior face of tangential tubes.

H-W INSULATING REFRACTORIES



Included are seven classes of insulating fire brick, having service limits of 1600°F. to 3000°F; mortars for laying insulating brick; several brands of castable insulating refractories; H-W BLOCK INSULATION; H-W FINISHING CEMENT; and H-W MINERAL FIBER COATING.

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Harshaw Catalysts do a giant's work and Harshaw produces catalysts in giant quantities—carloads every week. A letter or phone call will put our 20 years' experience and acres of production and research facilities to work for you.

PREFORMED CATALYSTS

to fit special process requirements

Hydroforming • Cyclization • Oxidation • Dehydrogenation • Dehydration • Desulphurization • Alkylation • Isomerization • Hydrogenation

CATALYTIC CHEMICALS SUPPLIED BY HARSHAW

Aluminum Nitrate — Cobalt Nitrate
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Manganese Nitrate Solution
Metallic Soaps (Cobalt, Manganese)
Nickel Carbonate — Nickel Formate
Nickel Nitrate — Nickel Sulfate
Sodium Methoxide — Zinc Nitrate

Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

Write for Free Book

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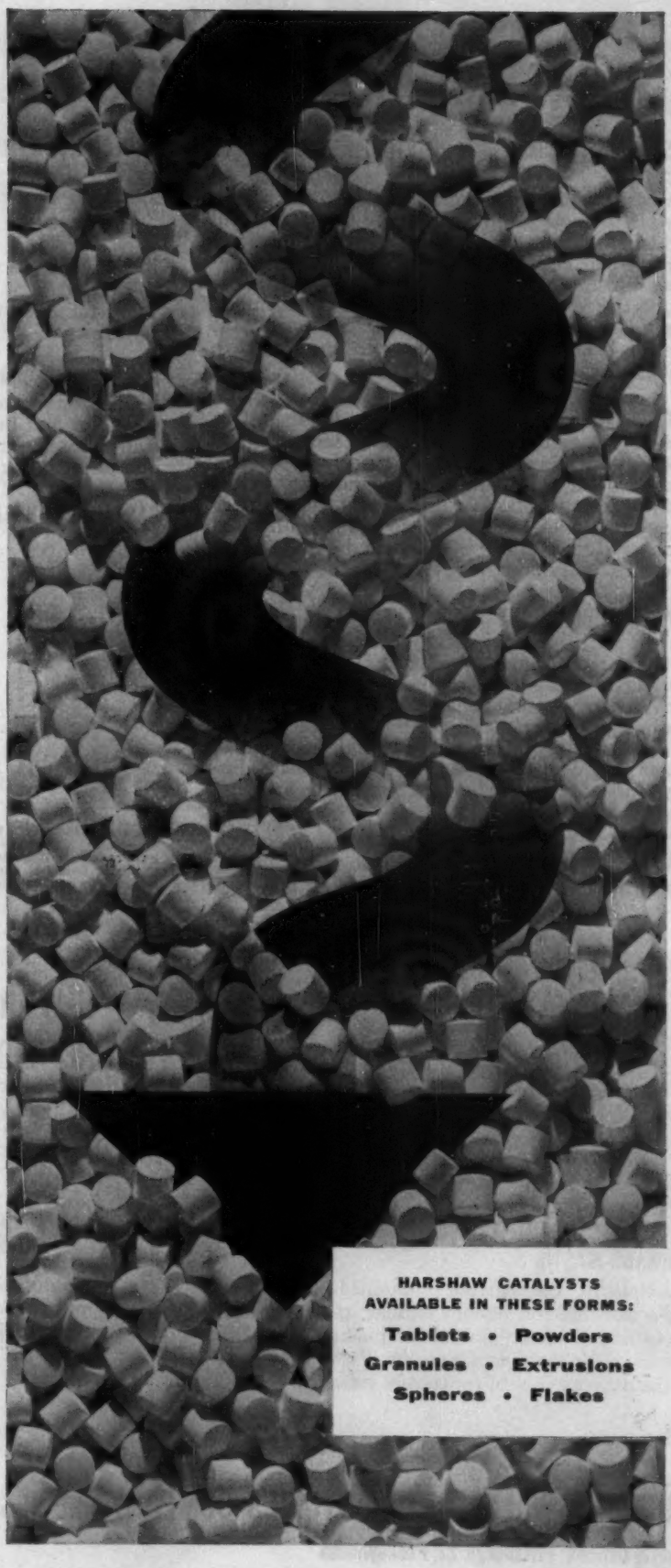

HARSHAW CATALYSTS AVAILABLE IN THESE FORMS:

Tablets • Powders
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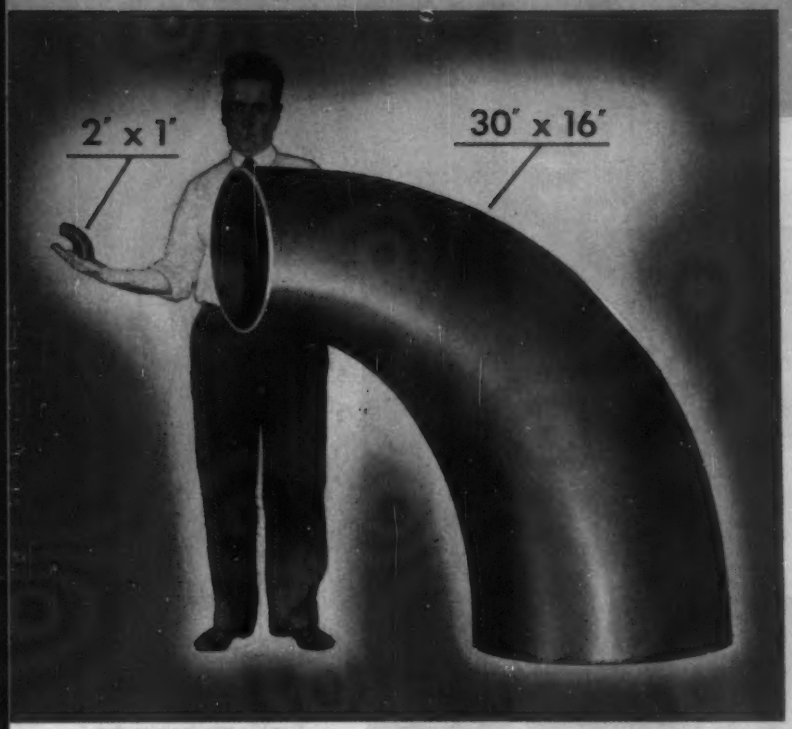
NOW . . . IN STOCK . . . NOT SPECIALS

MIDWEST REDUCING ELBOWS UP TO 30″



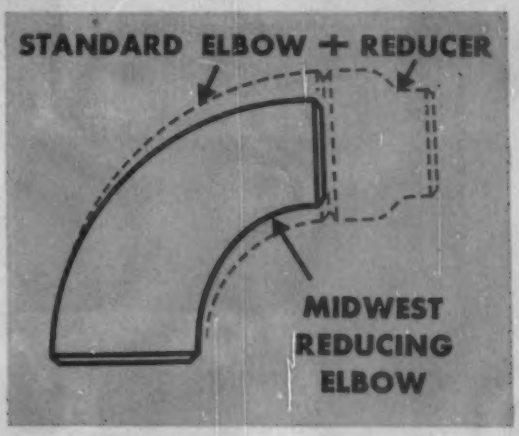
Your demand for Midwest Reducing Elbows has dictated our decision to make them STOCK items in all pipe sizes to 30″ OD and all reductions to one-half the nominal pipe size. We now have a modest stock of practically all sizes in standard and extra heavy weight, and this stock is being added to as rapidly as possible.

Midwest Reducing Elbows are also made as "specials" in heavy wall and/or any weldable alloy. The fact that our raw material is plate instead of tubing greatly increases our range of wall thicknesses and types of materials . . . it also improves the delivery.

Note the significant advantages of Midwest Reducing Elbows listed below. For further information, get in touch with the nearest Midwest Distributor or write us for Catalog 54.

✓ CHECK THESE ADVANTAGES OF MIDWEST REDUCING ELBOWS

- ✓ Save more than ⅓ of the welding required by standard elbows and reducers.
- ✓ Reduce turbulance and pressure drop because of gradual taper.
- ✓ Fit into smaller space than straight elbows and reducers.
- ✓ Greater piping design opportunities . . . easily adaptable for making special reducing fittings such as "bull-head" tees and back-outlet elbows.
- ✓ Improve appearance of piping.
- ✓ Available from stock in sizes to 30″ OD. (Heavy walls and alloys on special order.)



MIDWEST PIPING COMPANY, INC.

Main Office: St. Louis 3, Missouri (P. O. Box 433)

PLANTS: ST. LOUIS, CLIFTON, N. J. and LOS ANGELES

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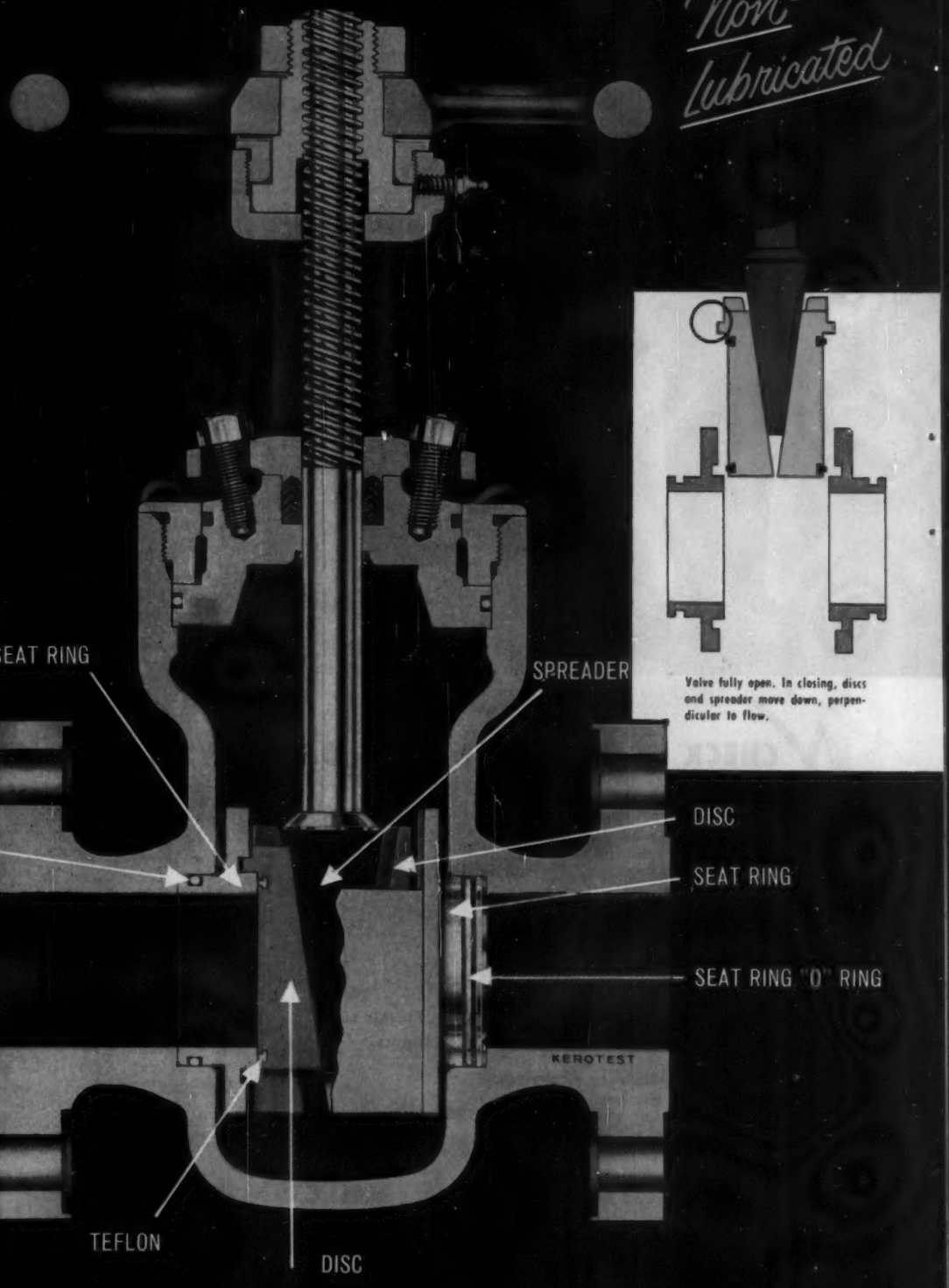
STOCKING DISTRIBUTORS IN PRINCIPAL CITIES

7462

This NEW vapor-tight, optional flow, *Non-Lubricated*

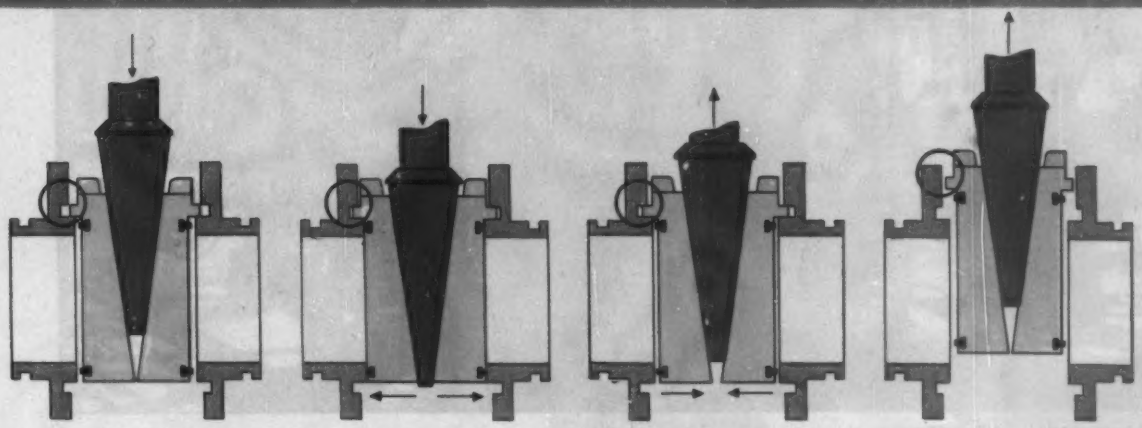


Valve fully open. In closing, discs and spreader move down, perpendicular to flow.

double block and bleed, full opening,

KEROSEAL® VALVE

handles gases, petroleum products and petrochemical fluids



Discs are positioned without drag across seat. When disc lug rests on seat ring, continued downward motion of spreader moves discs parallel to flow.

Valve fully closed. Spreader holds discs vapor-tight against seat rings.

Valve begins opening. Seated discs are retracted with the same parallel motion—again with no drag against seating surfaces.

Discs fully retracted, and assembly rising. Upward motion does not begin until discs are clear of seat ring.

More than two years of laboratory and field testing have clearly demonstrated the fact that the new KEROSEAL offers advantages not found in any other valve.

The KEROSEAL valve gives a vapor-tight seal without the continued and costly use of sealing lubricants. An effective new method of guiding the disc assembly, completely independent of the valve body, maintains clearance between discs and seat rings during operation, eliminating wear, frictional drag, wiping, and consequent galling of the seating surfaces.

Primarily, these advantages are the result of an entirely new principle of operation. The stem carries a spreader, on which are mounted a pair of discs. A Teflon sealing ring is mechanically bonded to each disc.

When the valve is being closed, the discs move downward, without friction. This downward travel automatically ends when discs are correctly positioned in relation to the seat ring. At this point, further movement of the stem initiates the spreader action, forcing the discs against the seat rings.

In opening, the first movement of the stem retracts the discs so that they clear the seat rings, and further movement raises the discs until they reach the fully open position.

The new KEROSEAL valve is described in detail in this new full-color bulletin. *Write for your copy today.*

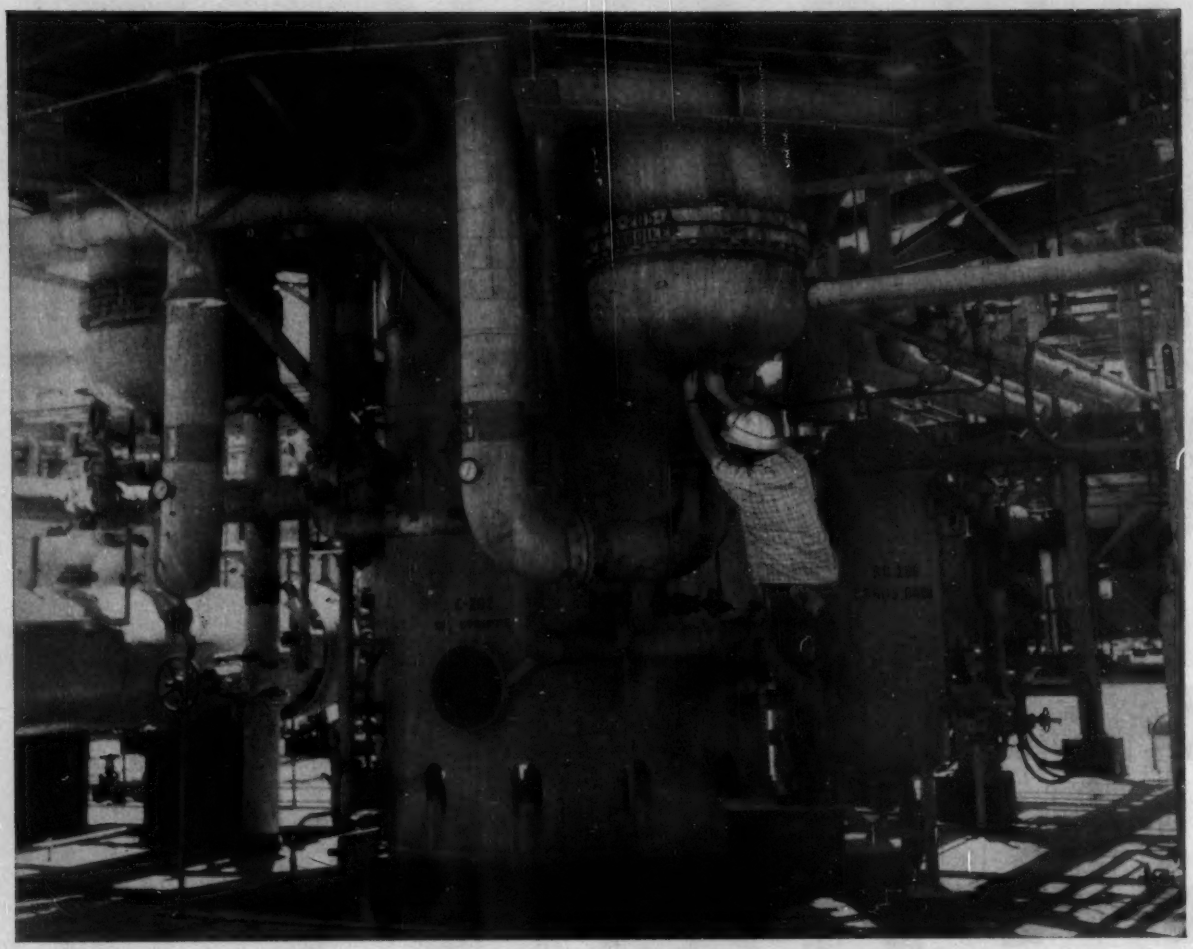
KEROTEST

KEROTEST MANUFACTURING COMPANY

2514 Liberty Avenue, Pittsburgh 22, Pa.

In Canada, Kerotest products are manufactured and distributed exclusively by Guelph Engineering Company, Guelph, Ontario.

Patent Applied For



Monel-protected . . . Reboilers on this column used for stripping CO_2 from monoethanolamine solutions at a Shell Chemical anhydrous ammonia plant contain Monel alloy tubes. Tubes have shown no significant corrosion in two years.

Little to do but turn the valves when MEA reboilers have Monel bundles

Shell Chemical checks CO_2 corrosion . . . descales only once in two years

This workman never had it so good.

Used to spend a good deal of time with the two reboilers on this column which strips CO_2 from "fat" monoethanolamine solutions. First he would dismantle one. Descale. Hook up again. Before long it was the other's turn. Every three to six months new tubes had to go in.

But that all stopped in 1954

Shell Chemical put in Monel* nickel-copper alloy tube bundles.

Since then, the reboilers have been descaled but once. What's more, deposits appear to contain no corrosion products . . . just stream precipitates. Tubes look like new . . . have never been replaced.

Take a leaf out of Shell Chemical's book

Inco's Corrosion Engineering Section will be glad to help you check into corrosive conditions within your MEA reboilers.

If Monel alloy is indicated for the tubes . . . and there's a good chance that it will be . . . put it in!

Then relax. Look at the meters. Turn a valve once in a while.

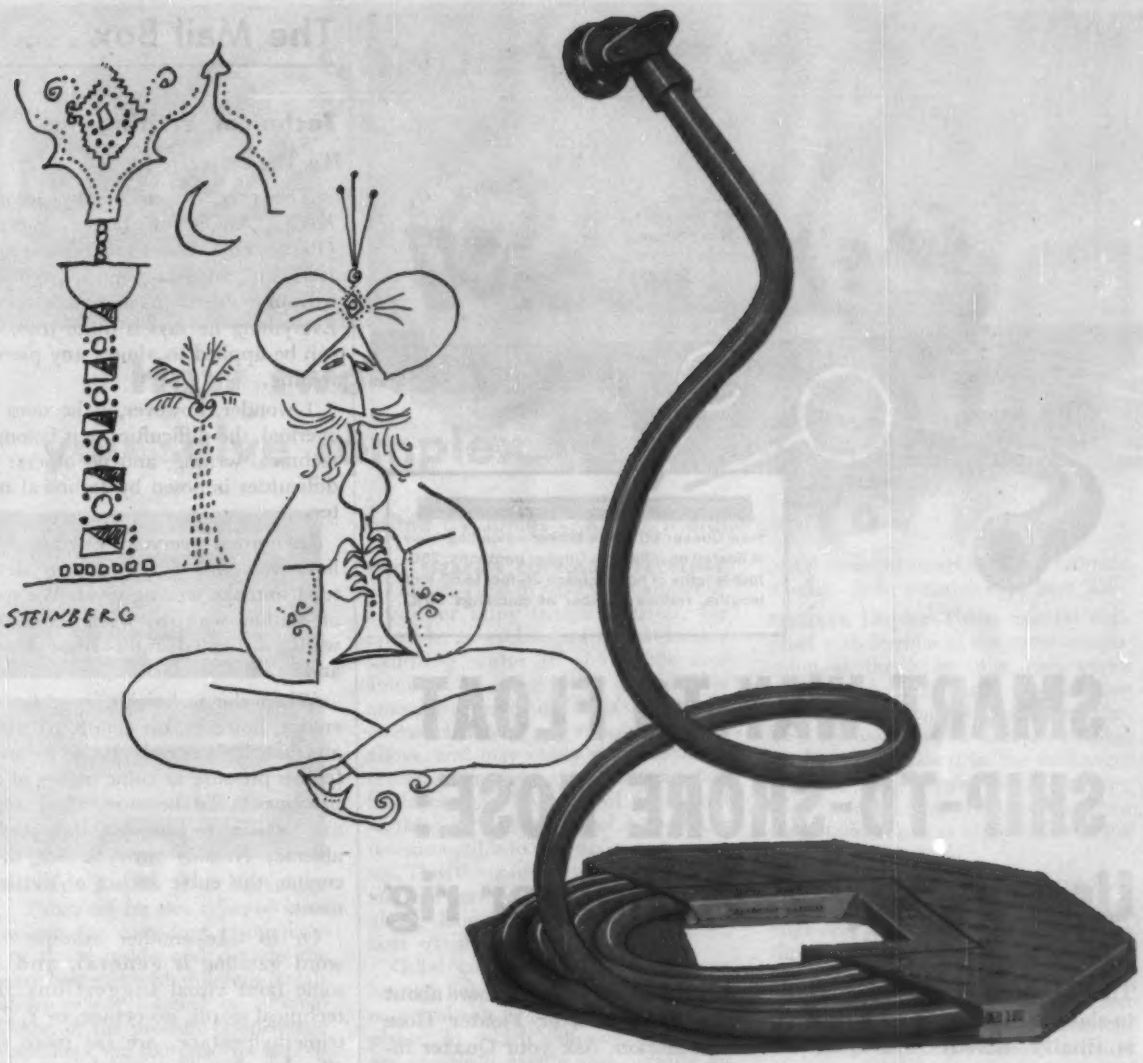
*Registered trademark

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

INCO TRADE MARK Nickel Alloys

Monel . . . *for minimum maintenance*

For more data on advertised products, use Readers' Service Cards, last page.



discipline

We discipline copper.

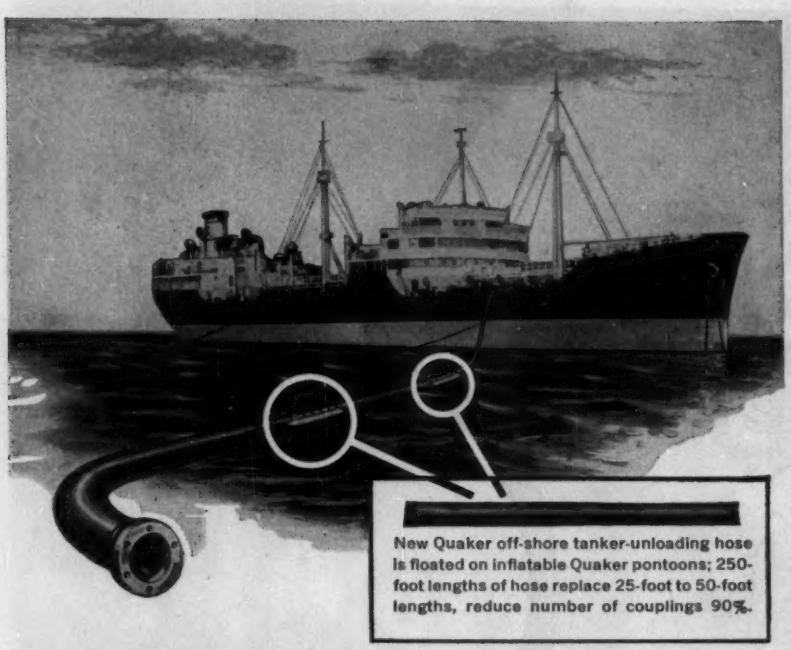
We put it through the roaring heat of our own smelter . : : the high-amp stillness of electrolytic refining tanks . . . the irresistible pressures of piercing mills and extrusion presses . . . the long reaches of our drawbenches . . . through coiling, annealing, straightening and testing equipment.

We work our will on copper—through every chemical change, every physical gyration known or needed—to deliver it perfect and enduring, yet submissive . . . as Lewin-Mathes seamless tube, pipe and fittings.

Like the ancient coppersmith, our pride of product is that of the *integrated specialist.* And the Lewin-Mathes nation-wide supply facilities serving you, we believe, are second to none.

LEWIN Ⓜ MATHES
SAINT LOUIS, MISSOURI
COPPER AND BRASS TUBE PIPE AND ROD
DIVISION OF CERRO DE PASCO CORP.

For more data on advertised products, use Readers' Service Cards, last page.



New Quaker off-shore tanker-unloading hose is floated on inflatable Quaker pontoons; 250-foot lengths of hose replace 25-foot to 50-foot lengths, reduce number of couplings 90%.

SMART WAY TO FLOAT SHIP-TO-SHORE HOSE:

Use this Quaker floater rig

The old nuisance of floating ship-to-shore oil hose on empty drums is finally licked. And Quaker licked it.

Now, with Quaker's new floater assembly, you do away with bulky, abrasive 55-gallon-drum pontoons . . . you reduce the number of hose couplings as much as 90% . . . and you make the loading or unloading of a tanker off shore a relatively simple job.

This assembly consists of a reel that propels 250-foot lengths of Quaker hose to or from the ship, floated on revolutionary *inflatable* Quaker pontoons which, deflated, take up only a quarter of the space once needed to store inconvenient, rustable metal drums.

It's a beauty of a time- and money-saver! Find out more about the Quaker-Porter Floater Hose Installation. Ask your Quaker industrial distributor for full information, or write *Quaker Rubber Division, H. K. Porter Company, Inc.; Philadelphia 24, Pa., or Pittsburg, California.*

19-foot Quaker pontoon hose folds up into less than ¼ the space taken up by drum.

H. K. PORTER COMPANY, INC.

QUAKER RUBBER DIVISION

The Mail Box . . .

Technical Writing

To The Editor:

The excellent article by John L. Kent "ABC's of Better Writing" (PETROLEUM REFINER, November 1957 Vol. 36, Number 11, page 361) will undoubtedly have a wide appeal. Everything he says is quite true, and can be applied to almost any piece of writing.

I wonder, however, if he does not overlook the difficulties that belong to technical writing, and no others: the difficulties imposed by technical matters.

In normal everyday English, I believe you will agree, precise details tend to make writing vivid. We speak of station wagon, with white side walls, a dented right front fender, and so on.

When the technician speaks of an engine, however, his details are highly abstract, for example, brake mean effective pressure or cubic inches of displacement. To be sure, these terms are *familiar* to him, but they remain abstract. Nobody has ever seen, in an engine, the cubic inches of displacement.

Or to take another example—the word gasoline is general, and has some faint visual suggestions. The technical words, iso-octane, or 2, 2, 4-trimethylpentane, are far more specific, but they do not evoke any visual image.

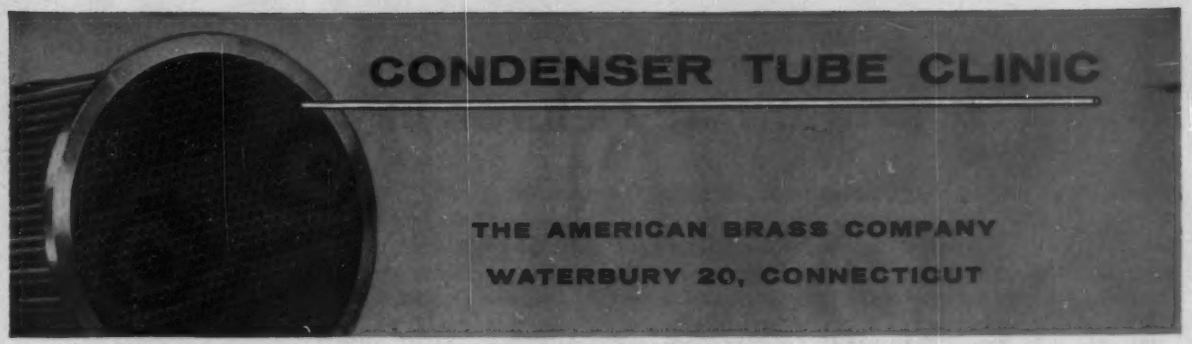
This means that the normal pattern of English is upset. Highly specific details can be abstract, and generalizations can be visualized.

To put it mathematically $3(2)^2$ is less general than nx^{n-1} but in an actual report the arithmetic notation could refer to thousands of details, (such as pricing of units) while the reference to calculus could control, one, single, precise detail—again, in an actual report.

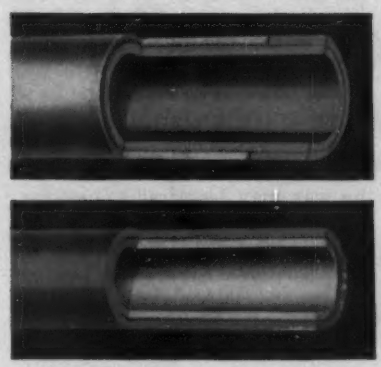
If this sort of thing interests you, you might also care to hear about my suggestions for organizing technical writing.

W. A. Sylvester
Editor, Technical Publications
Sales Technical Division
The Standard Oil Co. (Ohio)
Cleveland

For more data on advertised products, use Readers' Service Cards, last page.



How two-tubes-in-one can help you solve complex corrosion problems



ANACONDA Duplex Heat Exchanger Tubes are for two types of service—where the corroding characteristics of fluids inside and outside the tube are best met with different metals or alloys—where internal or external pressures, or the pressure-temperature combinations, are too great for a nonferrous tube alone. In the latter case, an Anaconda copper alloy with the required corrosion resistance is placed outside or inside a steel tube—and the pair is drawn together. The finished Duplex Tube has the chemical properties required for the more corrosive fluid handled—plus the needed strength.

Edited by James T. Kemp, Metallurgical Engineer

TWO SEPARATE CORROSION PROBLEMS. A Duplex Tube of steel with copper or a copper alloy inside is used, for example, in exchangers or condensers handling water in the tubes and ammonia or a fluid with appreciable amounts of ammonia in the shell. Moist ammonia attacks copper and all of its alloys, and may cause stress-corrosion cracking. Stresses may be due to applied loads or may be residual from cold working of the metal. Steel, however, is not susceptible to such action by ammonia. Thus the nonferrous tube is shielded and can perform its normal function of giving long service life and efficient heat transfer on the "water side."

Other combinations of coolant—or heating fluid—and "stream" are found in petroleum refineries and chemical plants, in which differing properties are required inside and outside an exchanger tube. Here two nonferrous metals may be combined—a Cupro Nickel and Admiralty, for example.

HEAT TRANSFER. Duplex Tubes have thermal transfer characteristics somewhere between those of the two metals used. Each face of the tube has the receptivity-emissivity of its metal. The metal-to-metal interface is so intimate it offers little resistance to heat flow.

FERRULES. Duplex Tubes can be supplied with ferrules of the same composition as the inner tube (see upper illustration), replacing a short section cut from the end of the outer tube. This ferrule prevents excess corrosion of the ends exposed in the exchanger channel. The ferrule should be long enough to be securely rolled in when the Duplex Tube is expanded into the tube sheet.

TECHNICAL ASSISTANCE. The American Brass Company's metallurgical engineers and its sales representatives throughout the country are available to help you in the selection of the Anaconda Condenser Tubes to meet your problems. Write: Technical Department, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 8070 REV

ANACONDA®
Tubes and Plates for Condensers and Heat Exchangers

PHYSICAL PROPERTIES OF ANACONDA CONDENSER TUBES*

ALLOY	Tensile Strength, psi	Yield Strength at .5% Elongation Under Load, psi	Elongation in 2", %	Rockwell Hardness, B Scale	Density, Lb. per Cu. In.	Thermal Conductivity, B.T.U./Sq. Ft./In./Hr./°F. at 68° F.	Average Coefficient of Linear Thermal Expansion per °F. (77-572 F.)	Modulus of Elasticity in Tension, psi
Arsenical Admiralty-439	52,000	20,000	60	6-45	0.308	768	.0000112	16,000,000
Ambraloy-927	60,000	20,000	55	35-65	0.301	696	.0000108	16,000,000
Ambraloy-901	60,000	28,000	55	30-60	0.295	540	.0000099	17,000,000
Cupro Nickel, 30%-702	55,000	22,000	45	30-60	0.323	180	.0000090	22,000,000
Cupro Nickel, 10%-755								
Light Annealed	44,000	22,000	46	25	0.323	312	.0000093	18,000,000
Light Drawn	60,000	57,000	15	68				
Red Brass-24	42,000	15,000	50	0-30	0.316	1104	.0000104	17,000,000
Ambronze-421	46,000	20,000	55	0-30	0.316	828	.0000102	17,000,000
Phosphorized Arsenical Copper-108								
Light Drawn	40,000	35,000	20	20-50	0.323	1344	.0000098	17,000,000
Hard Drawn	54,000	50,000	8	50-70				
Phosphorized Copper-103								
Light Drawn	40,000	35,000	20	20-50	0.323	2364	.0000098	17,000,000
Hard Drawn	54,000	50,000	8	50-70				

*Note: The above values are approximate and should not be used for specification purposes. *Light annealed except as noted.*

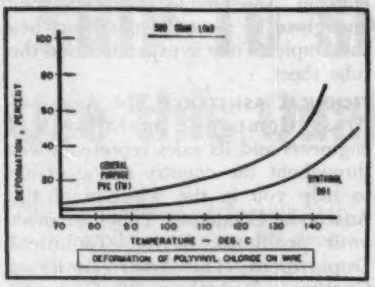
For more data on advertised products, use Readers' Service Cards, last page.

Troubled with wiring failures in your refinery?

If so, consider the record being established by Rome Synthinol 901, a special 90° PVC compound for wire insulation and sheathing. It has helped to solve an impressive list of difficult wiring problems.

Developed by Rome Cable's laboratory and first introduced in 1949, Rome Synthinol 901 has proved by test and actual use to be superior to conventional PVC compounds in the following ways:

a. Suitable for continuous operation at higher temperature (90°C).
b. More stable under severe heat cycling.
c. Suitable for continuous immersion in hot transformer oil.
d. Superior resistance to chemicals and solvents.
e. Greater resistance to heat deformation.



Graph shows heat deformation vs. temperature, and compares Synthinol 901 with conventional PVC compounds. Test run in accordance with Underwriters' Laboratories standard procedure, except for temperature.

The practical value of this compound can best be illustrated by describing a number of actual case histories.

(1) Oil refinery, industrial and chemical plant wiring.

Plant and oil refinery engineers have long used conventional PVC insulations for plant wiring with good results, but too often heat deformation problems arose in warm locations. Since Rome Synthinol 901's superior deformation resistance suggested that it might be the answer to this problem, it was tried and soon became widely used because of its much better service record.

Synthinol 901 also proved to be far superior to conventional materials for chemical plant wiring where the corrosive action of chemicals and solvents has always been a tough problem. Although polyvinyl chlorides as a class have inherently better resistance to chemicals and solvents than many other materials, some engineers desired even further improvement. One user decided to test a number of samples over a long period by immersing them in various concentrations of acetone, different alkalis, and butyric, propionic, and acetic acids. The results of this careful evaluation showed clearly that, when exposed to these chemicals, Synthinol 901 would last longer than any other PVC tested.

(2) Oil-filled transformers.

Transformer engineers have long sought a cable construction to replace varnished cambric-insulated cable for leads in oil-filled transformers. These leads connect transformer windings and bushings and are constantly immersed in hot oil. One transformer manufacturer, encouraged by successful experience with Synthinol 901 on other applications, undertook a comprehensive study of the possible usefulness of this insulation in lieu of varnished cambric for high-voltage transformer leads. This study extended over a several-year period and proved to those engineers involved that there were at least four reasons for standardizing on Synthinol 901 for this application:

a. There was less sludge in the oil than when VC insulation was used.
b. There was no harmful degradation of the electrical properties of the oil.
c. Conductors insulated with Synthinol 901 ran cooler, permitting a 7% increase in lead cable current rating.
d. The use of Synthinol 901 in lieu of VC would permit substantial dollar savings.

(3) Coil leads.

Many manufacturers of small coils for relays, small transformers, small motors, and electronic components have tried to use PVC insulated lead wires for many years. Typically, these leads are crimped or soldered to the ends of the coil; and the whole coil is then impregnated with varnish or wax and baked as long as 16 hours at temperatures as high as 150° C. The varnish used may be asphaltic, phenolic, alkyd, etc.; and the wax may be paraffin, beeswax, carnauba, or another kind.

PVC insulated lead wires frequently produced serious production problems because of the insulation's tendency to shrink, crack, and stiffen during the impregnation and subsequent baking period. Synthinol 901 was substituted in place of the ordinary PVC insulation and, after nearly eight years of wide usage, not a single case of shrinkage, cracking, or stiffening of insulation involving Synthinol 901 has been brought to our attention.

These case histories describe just a few of the applications for which Rome's Synthinol 901 has proved especially effective. Perhaps they will suggest other applications in your own area which might also be better handled with Rome Synthinol 901 instead of a conventional PVC compound. If you have a wire or cable problem that might be solved with Rome Synthinol 901, why don't you get in touch with us? Contact your nearest Rome Cable representative for more information—or write to Department 320, Rome Cable Corporation, Rome, N. Y.

ROME CABLE
CORPORATION

A Quick Look at the Industry THIS MONTH

Imports, Plus Soft Markets, Equal Refinery Shutdowns . . . Despite heavy cuts in refinery runs, large and small refineries alike are feeling brunt of excessive product inventories and weak price structures. Trouble stems from two sources:

- Warm winter. In mid-January major product demand was 5.5 percent under year ago levels. And prospects for '58 indicate no increase in runs during first quarter, possibly first half.
- Crude and product imports, though improved by voluntary controls, continue to weaken already weak petroleum markets.

Result: Refineries are either cutting runs sharply and laying off personnel, or shutting down completely. Here's partial box score to date: **American Oil**—will lay off 150 employes by April; **Pure Oil**—laid off 106 of 535 employes; **Esso Standard's Bayonne, N. J. Refinery**—plans to lay off 800 of 1650 employes by March 1; **Corpus Christi Refinery**—shut down; **Clark Oil** (7000 bpd)—shut down; **Delhi-Taylor** (15,000 bpd)—shut down; **Gladewater Refinery** (2500 bpd)—shut down; **Cosden-Hawley Refinery** (7000 bpd)—shut down.

In effort to stem downward business trend, major oil industry groups are putting pressure on Washington to curb government product imports from Caribbean, put more teeth in voluntary import program.

Now You Can Float Your Oil to Market . . . According to British, flexible oil barges made from synthetic rubber and towed by small boat have panned out well in initial research stages. But, it's still too early to tell if they will be accepted as means for moving Middle East oil to Europe in place of present supertankers. Economics are not defiiite, though initial cost is one-seventh of conventional oil tanker. Next step: Increase size of test models.

Meanwhile, Reichhold Chemicals reports that floating tubular plastic bags will be made in U. S. soon to be used for transporting fuel oil or chemicals and towed by tugs. They say shipping costs will be reduced 60-80 percent. The giant bags will have capacity of 20,000 gallons, are 100 feet long and can be towed in line like a railroad train.

All That Glitters Is Not Safe . . . U. S. Navy researchers report explosions from sparks can be caused just as easily by tools made of such "non-sparking" materials as copper, as by tools made of steel. According to report, metallic sparks can be caused by contact between non-sparking and sparking metals—and impact is more dangerous as a source of ignition than friction.

New Markets for Asphalt . . . Recent research by Kerr-McGee shows that asphaltic fractions from reduced crude can be converted to good ion-exchange materials or activated char. Conversion was made by sulfonation-sulfation.

Army engineers say tests to determine whether asphalt runways can handle big jets may not be completed until August 1. Maximum weight load for test has been increased to 265,000 lb.—weight of latest B-52 bomber—from previously planned 240,000 lb.

Postings on Octane Race . . . Ethyl survey of major U. S. cities shows premium octanes averaged 98.4 for January, same as December average. Regular was down 0.1 octane for January average of 91.0.

As auto compression ratios approach 12:1, it seems surface ignition will be

competing with octane numbers as the most important gasoline spec. Unhappily, the components desirable for octane appreciation are bad for surface ignition resistance. In fact, best fuels known now won't eliminate surface ignition entirely. A lot more research will be conducted before problem is solved.

According to Sun Oil estimate, 21-million car owners are now paying for more octane than they need. Sun's "custom-blending" pump is now servicing company's customers in 21-state marketing area. Motorists have their pick of six grades of gasoline—all from the same pump.

Progress Notes on Avfuel . . . There's no fuel like an old fuel. Particularly when it is stored in ice. U. S. Army Corpsmen have found that avfuel not only retains its properties, but water content is reduced so that the avfuel actually improves when stored in pits carved in the ice. This revelation was made when Army team returned to their work in the Arctic after seven months.

Instantaneous chemical analyses are made by new electronic instrument, the "time-of-flight mass spectrometer". It can analyze particles in 1/10,000th of a second. Speedy enough to analyze individual explosions of rocket, jet and internal-combustion fuels during engine operation, the device uses an ion gun to identify vaporized gases, liquids and solids by revealing their molecular masses. Analyzed molecules are followed the length of the gun tube, their speed measured electronically and plotted on an oscilloscope.

Quick Look at Washington . . . Fate of Harris-O'Hara bill may be decided early in March; early January optimism regarding bill's chance of passage has taken a reverse tack—government officials now say vote will be close with failure or success of compromise coal amendment very possibly deciding the outcome . . . **Imports Administrator Carson is up in arms** about "alleged" imports of crude without obtaining government quotas—says refiners who continue to ignore voluntary imports plan might subject entire industry to high imports tariffs or mandatory controls . . . **Union Oil of Calif. has officially protested** bids submitted to Military Supply Agency from Aurora, Cosden and Shamrock—as "small business" operations—protest claims these companies are *not* small . . . **Mid-January Military Supply Agency bidding** on JP-4 contracts saw price quotations at lowest level in Agency's history; Caribbean quotations ranged from 7.32 to 8.22 cents per gallon, while U. S. prices ranged from 8.34 to 9.61 cents per gallon.

Stiff Labor Demands on the Way . . . After "comparatively" cooperative year in 1957, independent labor unions plan tight squeeze on oil companies this year. Reason: Strong bait is needed to increase union membership. To give one example, 60,000-member Federation of Independent Oil Unions will bargain for such "Gravy" items as 35-cent per hour wage increase across the board, four-day work week, decrease in number of layoffs, elimination of forced retirement, improvements in benefit programs.

U. S. Is Biggest Rubber User . . . More than 46 percent of the world's rubber production is consumed in the U. S. The U. S. produces more than 84 percent of the Free World's synthetic rubber and consumes more than 63 percent of it.

While the U. S. produces no natural rubber, it consumes more than 31 percent of the world's production.

A **Buell Cyclones** offer exclusive Shave-off which harnesses double-eddy currents and puts them to work, large diameter design which eliminates bridging and clogging.

B **Buell "SF" Electric Precipitator** delivers extra collection efficiency through use of unique high emission, selftensioning Spiralectrodes and exclusive Continuous Cycle Rapping.

C **Buell Combination Cyclone-Precipitator Systems** combine exclusive Buell features for extra efficiency where extremely high performance standards must be met.

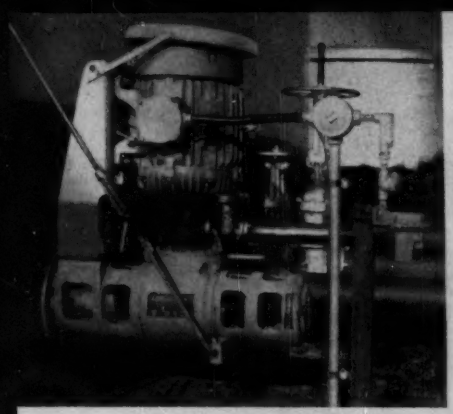
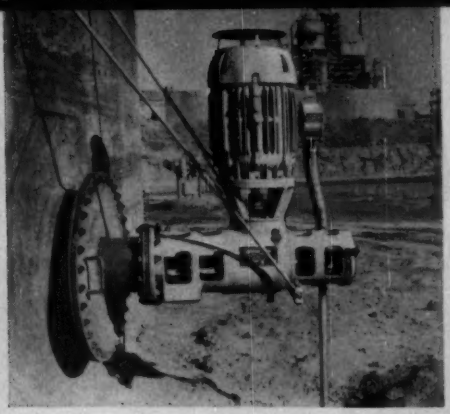
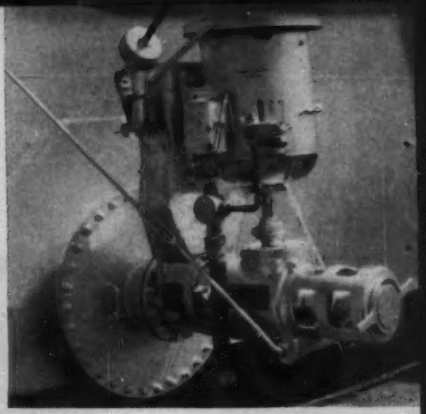
Which is the best dust collection system?

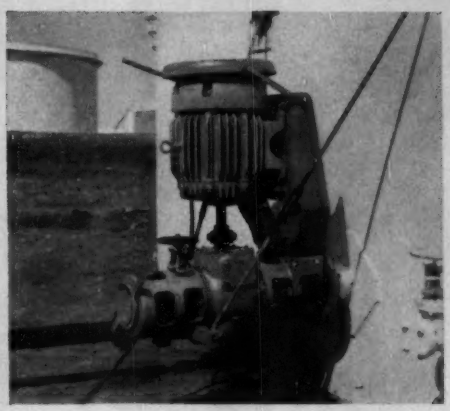
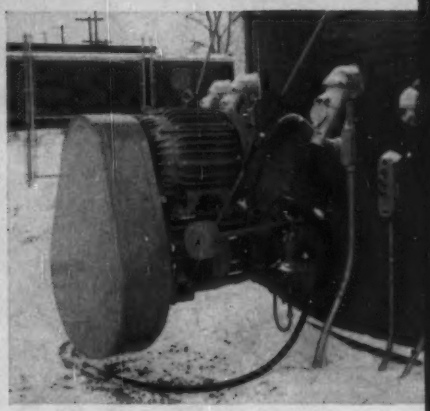
Five factors influence the choice of a dust collection system: dust characteristics, gas characteristics, efficiency required, installation and operation costs, and limitations of space or draft loss. In every installation, exclusive Buell features provide *extra efficiency*. A booklet, "The Collection and Recovery of Industrial Dusts", provides valuable, specific details. Just write Dept. 21-B, Buell Engineering Company, Inc., 123 William Street, New York 38, New York

buell

Experts at delivering Extra Efficiency in **DUST COLLECTION SYSTEMS**

For more data on advertised products, use Readers' Service Cards, last page.

Puzzle: *find the mixer that costs least to operate*

Specifying the *right* mixer for blending, TEL addition, or crude oil sediment control may *look* like a puzzle—but it doesn't have to *be* one.

Simply look for the mixer that gives you *most choice* for the money. That's the one most likely to give you the long-run economy you're seeking.

For example, if corrosion is a problem, you'll want a free hand in choosing the material for the mixer shaft and propeller. It's good to know you can get these parts in *any* machinable metal or alloy (and with special covering, if you want it) —when your choice is a LIGHTNIN Mixer.

Leak-free sealing—Perhaps you've taken a close look at maintenance costs, and decided you'd like a mixer with a rotary mechanical shaft seal instead of a stuffing box. You can get such a seal on any LIGHTNIN Side Entering Mixer (it's saving many oil companies thousands of dollars a year on maintenance). Or you can take your pick of *four* standard packed stuffing boxes, two of which permit repacking without draining the tank.

Choice of power input—What's your preference on mixer drive units? You can choose a highly efficient gear drive, or a lower-cost V-belt drive, for your LIGHTNIN Mixer. On gear-drive LIGHTNINS, you can have a fluid coupling between motor and drive to handle excessively high starting torques.

You want a mixer big enough to handle the job. But you *don't* want to pay for excess horsepower. With LIGHTNINS, you have a *full range* of sizes to choose from —18 basic models, 1 to 25 HP.

Finally, you can order LIGHTNINS with the motor that gives you best service and minimizes your stock requirements: any make with NEMA frame; any current characteristics; any enclosure or insulation.

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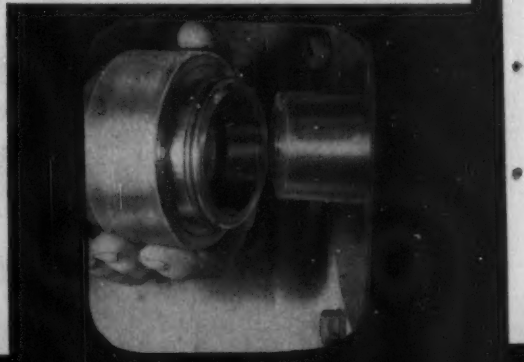


Data Nor Management Talks Enough

AS TECHNICAL MEN, we often think of projects as having to be sold to management. But equally important is the fact that projects need also be sold by management to technical men—not with platitudes but with specific economic information. Speaking for research departments in the industry, Dr. P. C. White, manager of the Standard Oil Company (Indiana) research department, put the problem and solution this way at the recent AIChE annual meeting:

"Supposing your company encounters a new competitive pressure; Sales turns to Research to help. Top supervisors confer on the program needed. It is set up and the men assigned. Are they told why, and how soon, and how badly the results are needed? Or a technical man may make a suggestion to a supervisor. It may be a very good one. The supervisor may, in turn, pass it on up the line to see what his boss says about it, but he is a busy man and sometimes he forgets to follow up. It can happen that the research man who made the suggestion never hears why it was not adopted. Or perhaps a high-level project status report on an existing project is made in a conference with members of the Sales department and Manufacturing department present. The next week word comes down that the project direction is abruptly modified or perhaps is even terminated as a result of management decision. No explanations are given as to the reasons for such a change.

"We've all heard of cases like these—though I'm sure they never happen in our own companies. We are all aware that few things in technical work can be more frustrating and have a worse effect on the morale of the professional people. . . .

The Why of It. "Why does this situation exist? Personally, I believe it may be due to a very human tendency to identify ourselves with our earlier background. The knowledge we acquire through experience is acquired so gradually we tend to forget how much we've learned. Or perhaps we're not quite willing to admit to ourselves how raw we were when we started.

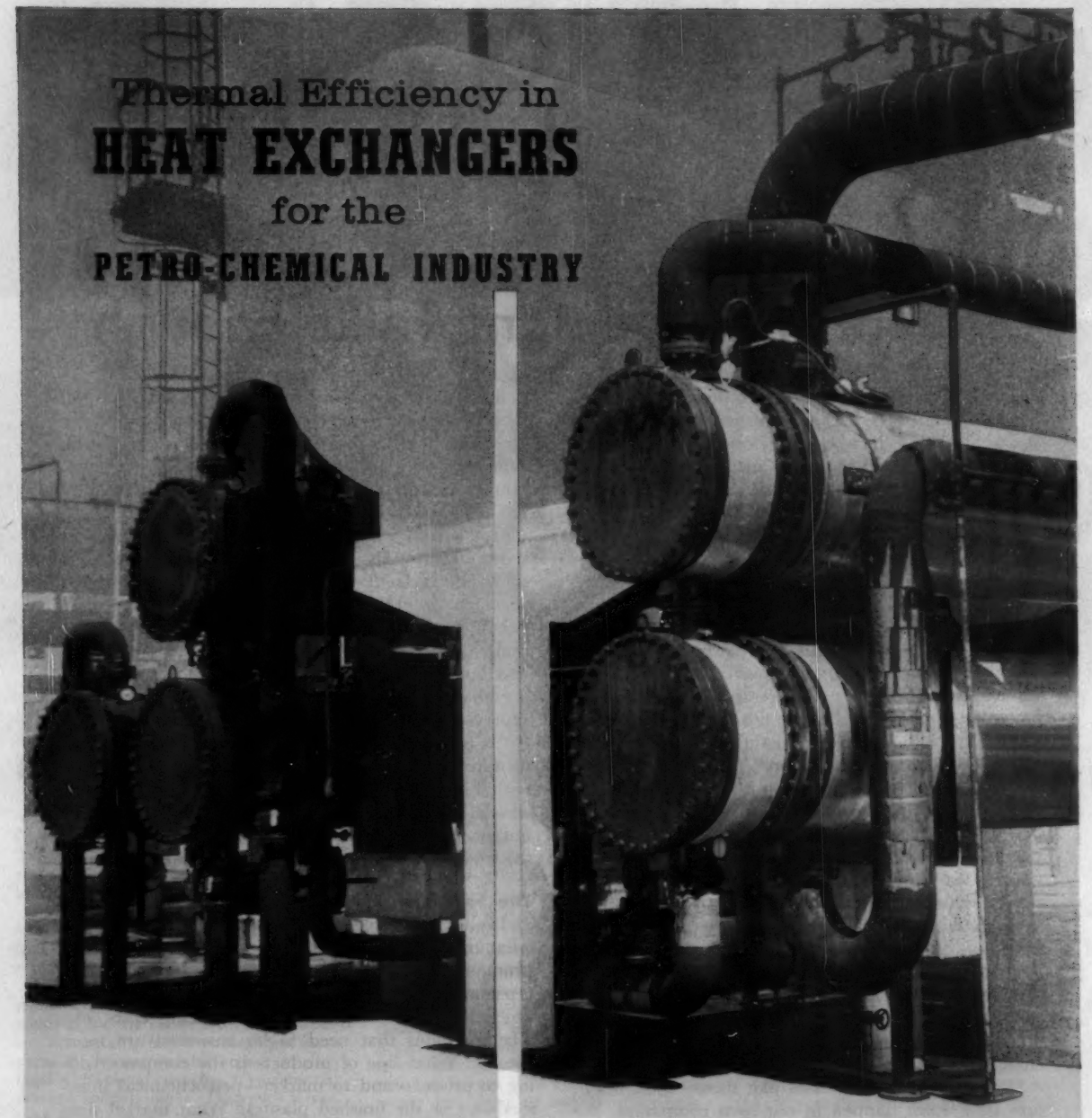
"The average technical man goes through school and then starts to work in a company. He knows chemical reactions. He knows the laws of mathematics and chemical engineering. But he knows nothing about company history. He knows nothing about its policies, about the economics of the industry in which he is working. He isn't conscious of political factors or of competitive pressures. He has not seen the development of quality trends. This information he acquires through decades of experience. But after he has acquired it, he still tends to identify himself with that new technical man at the bench. He ignores the substantial overlay of experience that separates them.

"When he initiates a particular research project, or when he judges a recommendation of an individual or group in the Research department, he naturally does so on the basis of his universe of technical and business background. His mistake lies in assuming that all the technical men working under his supervision share a similarly full understanding. . . .

"It is truly hard for the senior research supervisor to appreciate how wide the gulf is between himself, with his years of experience, and the younger man who shares his technical background and enthusiasm but who lacks his almost intuitive understanding of the whys and wherefores of the research program.

The Solution. "If we are going to bridge this gulf and solve the problem of downward communications, what must we do? Well, one thing, obviously, is to promote the establishment of company objectives by top management. This means more than generalized objectives; improving products, reducing costs, etc. The questions that need to be answered are more specific. What line of products is the company willing to produce and to market—petrochemical intermediates or the finished plastics? What market does it seek—industrial, retail, large volume only, foreign? How large a volume of business does it plan to achieve five years hence? What share of the market does this represent? Does the company hope to obtain markets by improvements and cost reductions in the present line or by new products? To what extent is it willing to consider licensing possibilities as an incentive for a research project? Are purely protective patents an objective? The answers to these questions give the technical man confidence in setting up his program to meet his company's needs. If he does not have the answers, he should work with his management in developing them.

"In addition to having the objectives set down in writing for all to see, the top management should back them up with a continuing flow of information on company policies, changes in plans, competitive



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trends as seen from the management level, economic trends, etc. In such an atmosphere of being part of the management team, the research man cannot complain that he doesn't understand what the company expects of him.

"With the company objectives set, it is obvious that the objectives of indiviual projects can be related to these company objectives. The questions that should be asked at this stage include:

"(1) Is this project in a field where we currently have sales or manufacturing interests? If it is outside, what risk are we running competitively and financially?

"(2) Is the work we are doing really new or are we developing someone else's idea? What are the opportunities for basic patent protection?

"(3) Do we see any new approaches to this general problem?"

Other departments besides Research can well heed these observations by Dr. White. Data don't talk and neither does management talk enough.

Historians On the Trail

WE ON PETROLEUM REFINER are thinking about history these days what with the 100th Anniversary of the Drake discovery well just around the 1959 corner. Staff members long since received their asignments and much work has been done toward rounding up some interesting historical articles with the slant, of course, toward refining.

Along this general line, we recently noted that a generous reward is being offered for "Dead-Arm Brandt," a "dime novel" that had its moments around the turn of the century. It's a thriller about the early oil days and we are told that collectors will pay upwards of $100. a copy to any who, looking where yesterday's teen-agers used to hide them, come up with a volume.

Purple prose and bad grammar notwithstanding, many of the stories of which "Dead-Arm Brandt" is a sample were written by men who had something of a first-hand knowledge of their subject. They are said to contain accounts of how nitroglycerin was used to shoot oil wells, early refining methods, and the financial risks day-before-yesterday's entrepreneurs took in a pioneer industry.

At least 15 dime novels dealing with oil have been uncovered so far and the hefty price tag attached to them are causing attics and cellars throughout the land to be scoured for new finds. Many students believe that these pulp books may prove of even more historic value than formal treatises because they managed to capture the spirit and flavor of the times.

Got any of these wanted characters around your ol' homestead?

Reducing the Robbery Toll

CASH REWARDS—substantial ones—for the apprehension and conviction of burglars and hold-up men victimizing its service stations has been found by The Standard Oil Company (Ohio) to be an extremely effective plan. In fact, it is so effective that the company, entering its second year of paying such cash rewards, has just announced a program that increases its top payoff from $2,500 to $5,000.

"This is a move to make an unprofitable business—hold-up and burglary—even less profitable," the company said in a statement. "Our records show that the average hold-up nets only $60 to the criminal. In station burglaries losses are even less because the intruders ordinarily get only insignificant amounts of merchandise and virtually no cash."

During 1957, the first year of the plan's operation, Sohio paid out $7,000 in 20 rewards to employes, dealers, law enforcement officers and other alert citizens. This total included 16 rewards of $250 each in cases of burglary, two rewards of $500 each in cases of armed robbery, and two rewards of $1000 each in cases of hold-ups involving physical injury.

Here are some convincing statistics:

The Cleveland police department reported that their city had 658 robberies during 1956 with 18 of them Sohio stations. During 1957, when Sohio's Shield Plan went into effect, Cleveland's over-all figure had jumped to 915 robberies but only 14 Sohio stations were included in this total.

Any plan that will cut down on this type of depredation is worth trying out. We wouldn't go so far as to suggest the old Texas Bankers Association plan of "$5,000 for a dead bank robber but not one cent for a live one" because that led to some tragic abuses, but the Shield Plan has a good experience that might be studied in other areas where this sort of thing is far too prevalent.

Big Company Doing Big Job

SOME OF OUR WASHINGTON FRIENDS think Du Pont is too big. But who, if the Du Pont Company wasn't doing it, would spend $15 million during a single year for fundamental research? This work has been going on for 30 years. So far as our knowledge goes, the 1958 appropriation against the three-decade background is the most extensive such effort ever conducted by any company.

Some 400 scientists are engaged in the Du Pont program which 30 years ago started with a corps of five men investigating molecular structure. Now it embraces organic and inorganic chemistry, biological chemicals, polymers and plastics, fibers and films, metals and alloys, electronics, solar energy, radiation chemistry and others.

Methods for making a new antiknock compound are investigated by an Ethyl research chemist.

How Ethyl Chemical Research Advances Antiknock Technology

Break-throughs in Organo-Metallic Chemistry Point to More Effective Antiknock Agents and New Tetraethyllead Production Methods

EVER SINCE the discovery of tetraethyllead as the first practical antiknock additive, Ethyl scientists have been searching for even more effective and economical antiknock agents.

Extensive research on both organic and metal-organic materials in our Detroit Research Laboratories has shown that the metals are the most promising. Our research also has shown that these materials promise important new advances in tetraethyllead production methods.

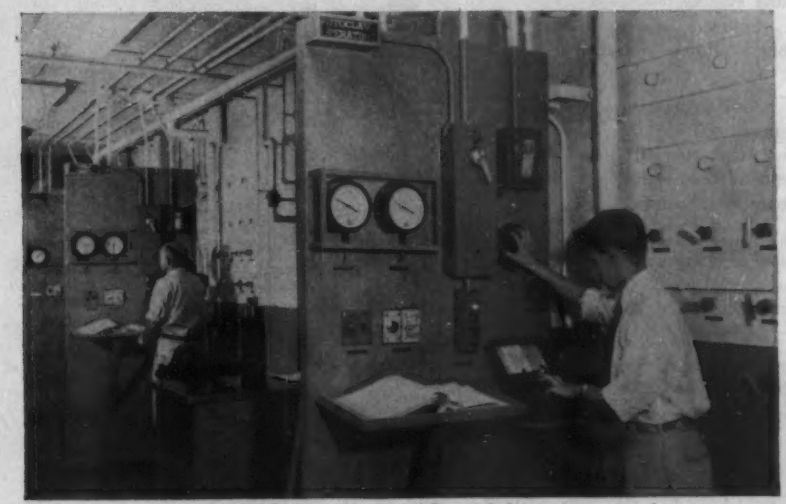
Our efforts to learn more about organo-metallic compounds also have enabled us to make significant contributions to chemical knowledge outside the antiknock field. Ethyl's continuing publication of such information contributes to the expansion of knowledge in this field of chemistry.

Developments in Organo-Metallic Chemistry Offer Antiknock Promise

Much of the early work on metallic antiknocks was hindered by the lack of compounds with solubility, volatility, and stability characteristics suitable for use in gasoline.

Recent chemical break-throughs, used to good advantage by Ethyl scientists, have indicated that many metals might be incorporated in organic compounds. The synthesis of organo-metallic compounds with suitable physical characteristics has enabled us to consider a number of them as antiknock possibilities.

One organic manganese compound, which we call AK-33X, has shown promise as an aviation fuel constituent to increase the power of piston aircraft engines. It is now undergoing extensive testing in both aircraft and automotive engines. Many oil companies are thoroughly examining AK-33X to determine its effectiveness as an antiknock and as a supplement to tetraethyllead in their different motor gasolines and constituents.



High-pressure autoclaves in Ethyl's Baton Rouge and Detroit Laboratories are used to run organo-metallic reactions at high pressures and temperatures.

Tetraethyllead Is Synthesized From Common Lead Compounds

Another recent accomplishment of Ethyl's organo-metallic research is a new method of synthesizing tetraethyllead from a wide range of organo-metallic compounds by reacting them with common lead compounds such as lead oxide, lead sulfide, and lead dioxide. This radical departure from present technology circumvents the use of sodium and chlorine.

Major development work remains to be done before this new method can be used commercially. However, our studies of all phases so far have led us to believe that considerable advances in tetraethyllead production methods are within reach.

Chemical Contributions Outside Antiknock Field

An added benefit of the synthesis of tetraethyllead and other organo-metallic compounds is the development in our laboratory of improved techniques for manufacturing triethyl aluminum. This compound is of high interest as a possible new route to the manufacture of tetraethyllead.

Triethyl aluminum also is important as an ingredient in catalysts for olefinic polymers and particularly high density polyethylene, as an alkylation agent for active metals and less active salts, and as a reducing agent comparable to lithium aluminum hydride. Triethyl aluminum and trimethyl aluminum also are being considered for military fuel applications.

The Ethyl scientific team has a solid research background in fuel-engine relationships plus a comprehensive knowledge of organo-metallic chemistry.

In addition, the Research Laboratories are uniquely organized to evaluate the potential engine applications of new fuel or lubricant additives. These are good reasons why we look forward to even more important advancements in the fields of antiknock chemistry and organo-metallic research.

In so far as possible, data on all Ethyl's current research projects in antiknock technology and organo-metallic research will be made available to the Oil Industry.

How Ethyl Research is helping you

In the 36 years since the discovery of tetraethyllead as the first practical antiknock additive, Ethyl's search for new antiknock agents has continued.

New compounds and their value to the Petroleum and Chemical industries are investigated on a continuing basis in our laboratories in Detroit, Mich. and Baton Rouge, La.

Research in the field of organo-metallic chemistry is only one of the many facets of Ethyl's research program.

Ethyl's scientific manpower, experience and facilities are dedicated to the search for fundamental knowledge of the behavior of fuels and engines, guided by the needs of the Petroleum Industry.

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What is the Bailey Building Block Method? It's using standardized Bailey measuring, transmitting, and controlling components and combining them into any system you need. Components can be added as needed . . . removed and reused elsewhere . . . recombined into another system when the need changes. It's flexibility plus!

It's all based on the simple fact that a Bailey instrument or control component doesn't care if the measured variable is steam flow, tank level, or tower temperature, to pick just three examples. System components—transmitters, receivers, relays, selector stations, power units—are standardized for multi-purpose use.

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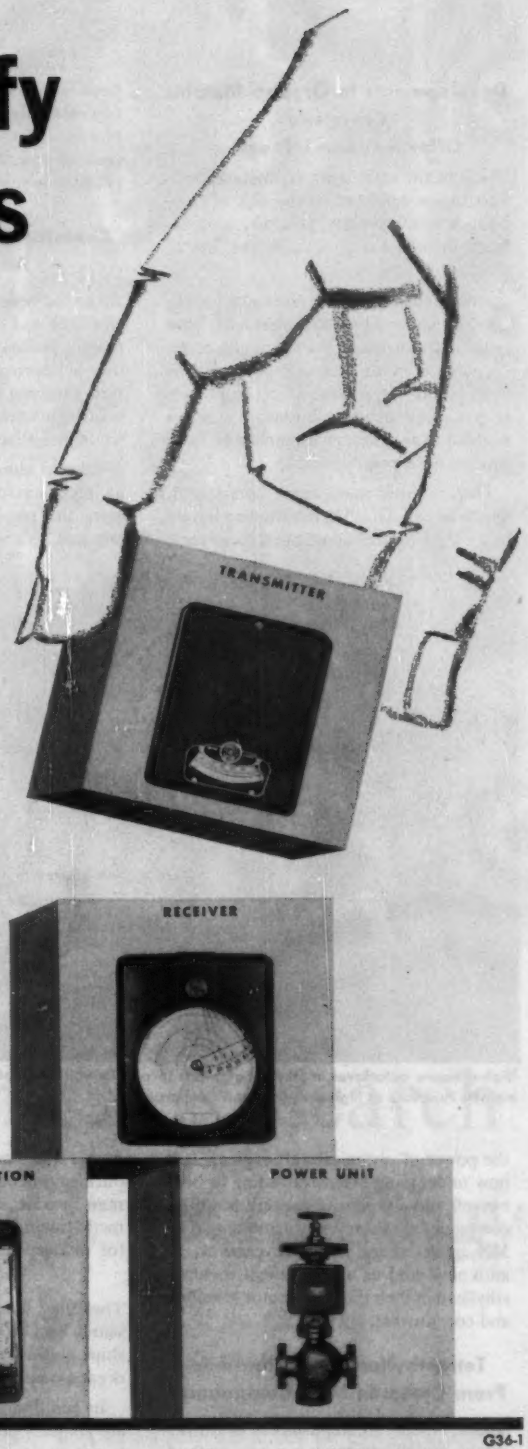
For further details, call our local district office or write us at Cleveland. Our engineers will be glad to prove how the Building Block approach will save you money and simplify your instrument and control problems.



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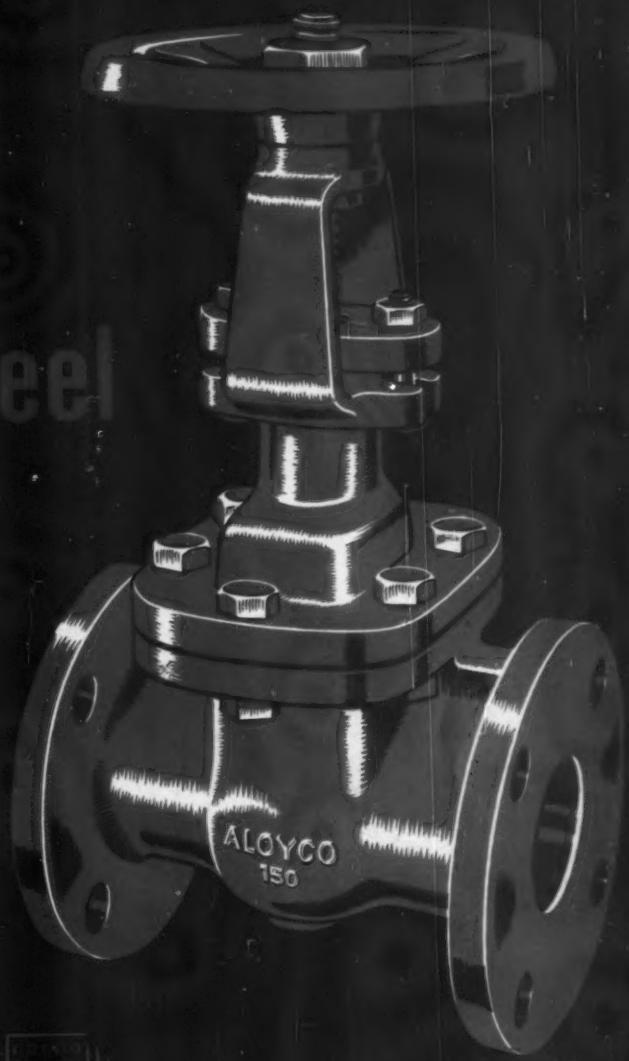

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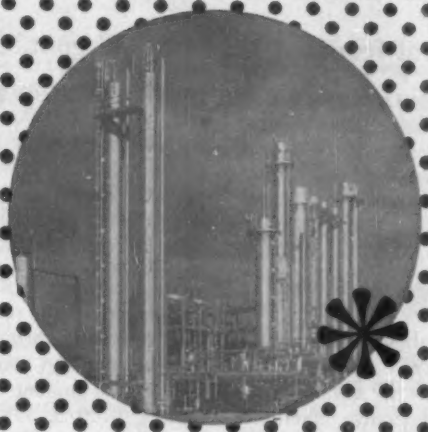

* a PETROLEUM REFINER Special Report

PERFORATED TRAYS ..designed this way

This comprehensive method for designing perforated trays includes the most reliable information from several sources. All of the equations you need are presented here, and many are reduced to nomograms to make the calculations easier.

Now you will have less trouble picking the optimum design. The nomograms let you examine a number of different tray situations quickly. To show you just how it works, the step-by-step procedure is used on a sample problem.

Limits are suggested for some of the dimensions. These are incorporated in a performance chart which helps you predict the range of satisfactory operation. The performance chart also can be used to rate an existing installation.

We are sure you will want to add this special report to your design file. Here is what it includes:

Contents

Meet Process Requirements.....104

Use These Design Standards.....112

Follow This Example Problem.....113

Predict Operation Performance....116

Perforated trays are used in several forms of vapor-liquid contacting: rectification, absorption, and stripping. This special report gives a step-by-step procedure to help you design them.

Chen-Jung Huang, University of Houston,
John R. Hodson, Texas Butadiene and Chemical Corporation, Channelview, Texas

PERFORATED TRAYS are used in many applications of vapor-liquid contacting with satisfactory efficiencies and capacities. Since the use of this type of tray[14,21,22,32] has been revived in the past few years, the most reliable data are brought together here to give a systematic procedure for tray design.

Plate efficiency is influenced by the tray layout and this factor should be considered in the tray design. However, the amount of information on plate efficiency available at this time does not permit a general correlation. Therefore the discussion on plate efficiency will be qualitative rather than quantitative.

The determination of an optimum tray layout from the viewpoint of tray dynamics should yield the following:

1. Insure required performance for the given process requirements.
2. Provide flexibility to meet possible future changes in process requirements.
3. Achieve the above at minimum cost of construction.

The application of a high-speed computer will, of course, facilitate the selection of an optimum design,[17] but the computations can be performed manually within a reasonable length of time with the aid of charts, tables, and nomographs.

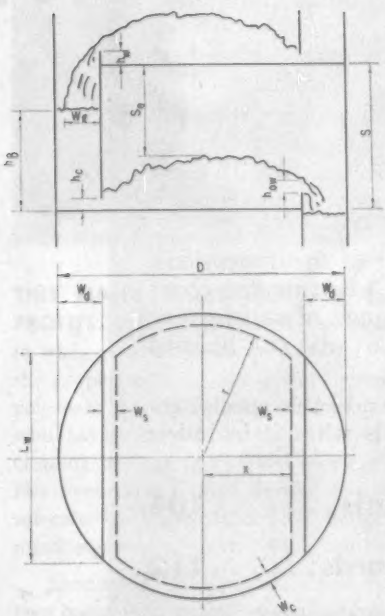

FIGURE 1—The main advantages of the perforated tray over the bubble-cap tray lie in its lower cost and in its simpler construction.

PROCESS REQUIREMENTS

One of the functions of fractionation and absorption calculations is to determine the vapor and liquid loadings and their conditions on the tray. From the known conditions of the vapor and the liquid, physical properties of both phases, such as density and surface tension, can be determined.

The effect of entrainment on plate efficiency and column performance has been discussed by many investigators.[2,3,7,8,11,25,37,38,39,40] Most of their equations result in lengthy expressions. Colburn[11] presented a simplified form to calculate an optimum entrainment attaining a column at minimum cost. For the plate in a fractionation column, Hunt[19] assumed that the molal entrainment ratio is approximately equal to the weight ratio, and he proposed the following form, as an extension of Colburn's equation:

$$e_o = \frac{L/V}{2E} \qquad (1)$$

Vapor and liquid loads in moles per hour are represented by V and L respectively.

The tray should be designed to meet not only the present process requirements but also the anticipated maximum and minimum loadings in the future. The limits of flooding and entrainment should not be exceeded at the maximum vapor and liquid loads, and the tray should be stable even at the anticipated minimum vapor load.

It is advisable to decide on a proper range of maximum and minimum loads according to the particular circumstances. If the ranges are not specified or known, arbitrary assumptions may be made. A tray whose diameter is 5 feet or smaller should be able to handle (100 ± 30) percent of the present process requirements; trays larger than 5 feet in diameter, (100 ± 15) percent.

For fractionation and absorption, the vapor and liquid loads on the top tray are usually different from those on the bottom tray. Therefore, for a complete design of the whole column, at least both the top and the bottom trays should be studied. In addition, it is often advisable to study the trays above and below the side streams and feed streams because of the sudden changes in the loads. Thus, it will be seen that although it is desirable from an economic point of view to have a uniform tray design for use throughout the column, this is not always possible. Possible solutions[4] in such cases may be:

a. To blank off the perforations in the tray where a low vapor load is anticipated.

b. To design entirely different trays (i.e. varying hole diameter, hole spacing, weir length, weir height, etc.) for different sections of the same column, keeping the tray diameters the same.

c. To vary the column diameter, employing an entirely different tray design for the different sections.

DESIGN VARIABLES, STANDARDS

Tray dynamic calculations must be made to insure satisfactory performance of a proposed tray design. Each of the items which would be considered will be discussed in the following sections:

Column Diameter. The first tray dimension to be determined is its approximate diameter. There have been a few empirical correlations[5,7,28] relating column diameters and vapor-liquid loads. The diameter determined by these correlations is an approximate one and it should be

improved by subsequent tray dynamic calculations until an optimum column diameter is attained. A tray diameter is reciprocally related to the tray spacing, the larger the tray diameter, the closer the tray spacing.

For determination of the approximate diameter of the tray, the Brown and Souder's method[7] may be used. Primarily, their equation for determination of the maximum allowable vapor velocity is:

$$G = K\sqrt{\rho_V(\rho_L - \rho_V)} \qquad (2)$$

Where G = Maximum allowable mass velocity of vapor, $\frac{\text{lbs.}}{(\text{hr})\ (\text{sq. ft.})}$
K = Empirical constant
ρ_V, ρ_L = Densities of vapor and liquid respectively, lbs./cu. ft.

The constant K may be obtained from Figure 2 as a function of liquid surface tension and tray spacing. Finally, an approximate column diameter can be estimated by the equation,

$$D = \sqrt{\frac{4}{\pi}\frac{V_M}{G}} = 1.13\sqrt{\frac{V_M}{G}} \qquad (3)$$

Where D = Column diameter, ft.
V_M = Vapor load, lbs./hr.

The tray diameter determined by Equation (3) is usually conservative. Based on this diameter, the first tray layout may be made. Then, by tray dynamic calculations, an appropriate tray spacing corresponding to the tray diameter can be determined.

Tray Types. Several patterns of liquid flow across a tray are used in industry. Sketches of the modes of liquid flow may be found in texts on distillation.

Cross flow with a rectangular weir is the most common. This flow pattern represents the simplest and most economical tray construction. Since the liquid flows directly across the tray, its long path contributes to high plate efficiency.

For low liquid and high vapor loads, a reverse flow tray is more desirable. The downcomers are located on one side of the tray. The liquid flows around a center baffle, reversing its direction at the other side of the tray.

In a double-pass tray, the total liquid load is split into two portions, each flowing across half the tray. This tray has a greater liquid capacity and consequently is more suitable for high liquid and low vapor loads. A triple-pass tray can be used for even a higher liquid-vapor ratio.

The preliminary choice of the tray-type is usually based on two factors, namely, the ratio of liquid-vapor loads, and the column diameter. A guide[4] for tentative selection is given graphically in Figure 3. The final selection of the tray-type should be made after the tray dynamic calculations are complete.

Aeration of Liquid. The phenomenon of aeration is the result of vapor bubbling through the liquid depth on the tray. The degree of aeration is an important factor in studying tray performance. Hutchinson and co-workers[20] have pointed out that it is the effective liquid height and effective liquid density which influence the tray performance such as plate efficiency, pressure drop, liquid gradient and entrainment. In a recent study on liquid phase efficiency, Gerster[18] and co-workers have used the froth height as a variable in correlation. Unfortunately, however, a reliable estimation of froth density is not possible at present.

Qualitative observation[32] showed that the clear liquid depth on the tray is one of the major variables which affect the degree of aeration. But the vapor flow rate has almost no effect on it in the region of stable operation. The relation of physical properties and the degree of aeration has not been reported. Hunt and co-workers[19] reported that the froth density was somewhere between ⅓ and ½ of the clear liquid density. The values are comparable with the measurement of others. The average value of 0.4 was used to determine the froth height on the tray.

Due to the difficulty in estimating the correct degree of aeration, the liquid heights in subsequent discussions are in terms of clear liquid unless stated otherwise.

Outlet Weir. The purpose of an outlet weir is to maintain an appropriate liquid depth on the tray. The straight weir is recommended unless the liquid load is very small. A weir adjustable from 1 to 2 inches is desirable because it gives wider flexibility for future service.

The specification of the length of weir should be such that at least ¼ to ½ inch liquid crest height is maintained above the weir to provide good liquid distribution. The most frequently used weir lengths are about 55 to 85 percent of the tray diameter for the cross-flow tray. The minimum liquid height which should be maintained on the tray is about 2 inches, as any liquid depth lower than this yields poor bubble formation. Good bubble formation produces a larger contacting area and a longer contacting time between liquid and vapor.

As shown later, the contribution of

Here's how they compare . . .

Advantages

1. Lower initial cost[14, 22]
2. Higher vapor rate[22]
3. Negligible hydraulic gradient and higher liquid rate[15]
4. Higher plate efficiency
5. Lower liquid entrainment[14, 16, 22, 26, 27, 32]
6. Simpler construction, replacement and maintenance

Disadvantages

1. Narrow range of stable operations[31, 33, 36]
2. Sensitivity to corrosion[14]
3. Collection of rust and sediment[14]
4. Perfect leveling[1]

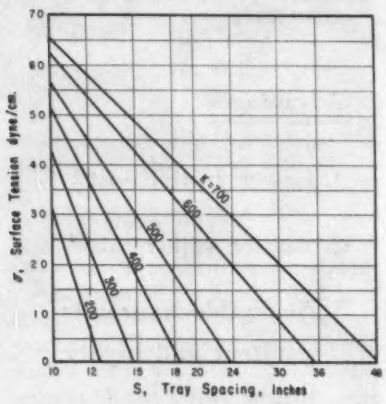

FIGURE 2—To solve for the maximum allowable vapor velocity, the empirical constant may be read from this graph.

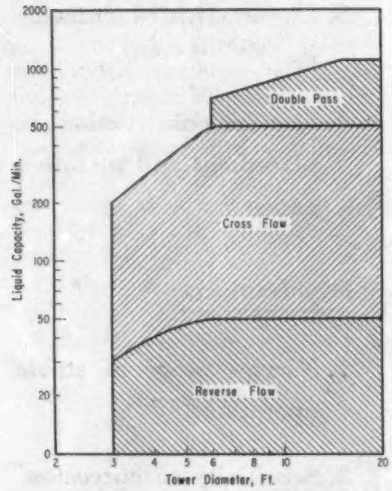

FIGURE 3—The type of tray is usually based on the loading and the tower diameter. Here is a guide to its selection.

clear liquid height to the liquid build-up in the downcomer is relatively large. A large clear liquid height also requires a large minimum vapor velocity to maintain stable operations. Therefore, it has been recommended[30] the clear liquid height should not exceed about 4 inches. The maximum weir height is, then, the difference between the maximum allowable liquid height and the liquid crest height over the weir. Since the minimum liquid height over weir, h_{ow}, is recommended to be 0.5 inch, the weir height in any case should never be higher than 3.5 inches. The limits of h_w, the weir height, are finally expressed as

$$4.0 - h_{ow} \geq h_w \geq 2.0 - h_{ow} \qquad (4)$$

Liquid Height Over Weir. The Francis formula has been used extensively to calculate the height of liquid over the rectangular weir

$$h_{ow} = \left[\frac{Q}{2.98 L_w}\right]^{2/3} \qquad (5)$$

But the curved side of the column wall has a constricting effect on the flow of liquid. Edmister[13] and Bolles[4] proposed means for the correction of this effect. However, the correction is not significant where the ratio of weir length and tray diameter is great. It is not considered in the tray dynamic calculations here. Figure 4 is a nomograph to facilitate the calculation of the liquid height over weir. The liquid heights over weir calculated at both maximum and minimum liquid loads should be within the following limits:

$$0.5 \leq h_{ow} \leq 4.0 - h_w \qquad (6)$$

Inlet Weir. The application of an inlet weir may improve the uniform distribution of liquid across the tray. But the liquid entering the tray from the segmental downcomer is distributed fairly uniformly without a weir.[4]

In some cases, in order to minimize impact effects, a recessed inlet weir is useful. Since maloperation may occur due to rust and sediment, the inlet weir may serve as a useful means of collecting the rust and sediment.

The inlet weir is usually specified to be about ¼ inch higher than the outlet weir.

If the downcomer clearance is greater than the clear liquid height on the tray at the minimum liquid flow rate, an inlet weir is necessary to produce the liquid seal which in turn prevents vapor blow-back.

Clear Liquid Height on Tray. The liquid height on the tray contributes to the height of the liquid build-up in the downcomer. Since the liquid gradient across the perforated tray is negligible, as discussed later, the liquid height across the tray is almost constant, if an inlet weir is not provided. As indicated in Figure 1 the clear liquid height at the outlet weir is the sum of the weir height and the liquid height over the weir.

$$h_l = h_w + h_{ow} \qquad (7)$$

For a tray specified with an inlet weir, the liquid height at the inlet weir should be calculated in a similar manner. In Equation (17) for calculation of the liquid build-up in the downcomer, h_l should be the liquid height at the outlet weir, or at the inlet weir when an inlet weir is used.

Downcomer. Because of the small downflow area, in a circular downflow pipe the liquid head loss through the downcomer is high, and vapor disengagement is poor. Therefore, at the present time, segmental downcomers are more widely used. In order to provide the maximum downflow area, Bolles[4] recommended that the tray support rings should not be extended through the downcomer. Sometimes the downcomer may be sloped, but a vertical downcomer is recommended for general use because of lower cost. Figure 5 is useful for determination of the downcomer area and width. An optimum dimension of the downcomer should be determined by the optimum balance between the downcomer area and the tray area arrived at by tray dynamic calculations. The most frequently used widths for segmental downcomers are from 7 to 20 percent of the tray diameter. For double-pass trays, the width of the center downcomer is usually from 8 to 10 inches.

Vapor blow-back should be prevented by providing a liquid seal at the bottom of the downcomer during the operation. This is why the clearance between the downcomer and the tray is usually specified to be less than the outlet weir by at least ¼ or ½ inch, if an inlet weir is not provided.

$$h_w - h_c = \tfrac{1}{2} \text{ or } \tfrac{1}{4} \qquad (8)$$

The clearance is also a factor which affects the liquid head loss through the downcomer. The liquid head loss through the downcomer should be less than 1 inch of liquid. If the specified clearance is too small, the limit may be exceeded.

Liquid Head Loss Through Downcomer. The liquid head loss through the downcomer should be small in a well-designed column. Edmister[13] and Cicalese[9] derived equations for calculating this loss. In his derivation, Edmister[13] assumed that one velocity head was lost on expansion and there was 0.5 velocity head loss in contraction as the liquid passes through the constriction of the downcomer. Cicalese's formula is for the liquid head loss through an orifice with a constant

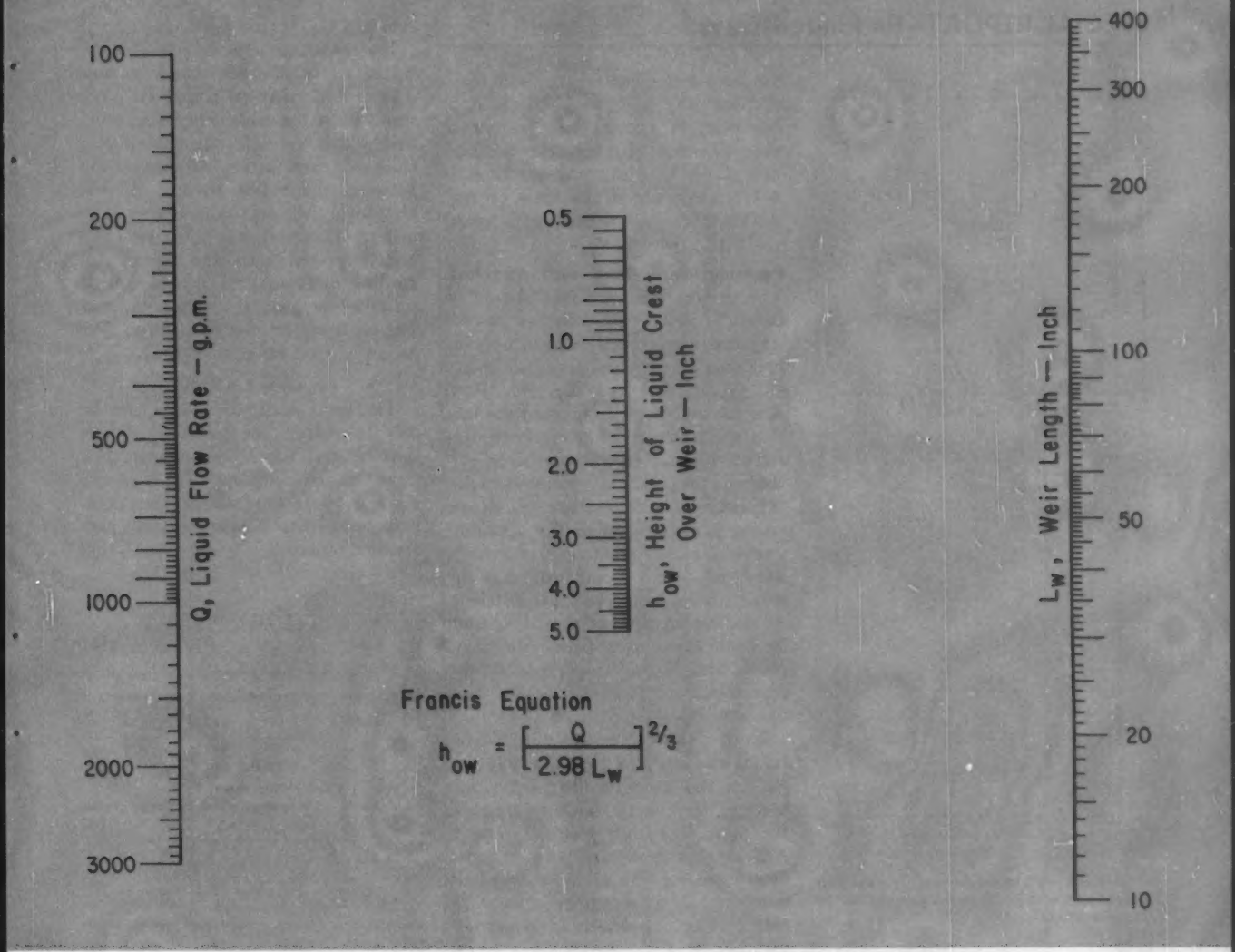

FIGURE 4—The determination of the liquid height over the weir may be done by nomograph.

discharge coefficient. Generally, the following equation is satisfactory:[9]

$$h_d = 0.03\left[\frac{Q}{100\,A_p}\right]^2 \qquad (9)$$

When an inlet weir is used, the equation should be modified. But the correction is too small to affect the amount of the total liquid build-up in the downcomer. "A_p" in sq. ft. is either the clearance area between the downcomer and the tray, or the downcomer area, whichever is smaller.

Calming Zones and Area for Perforations. A splash baffle was used by Peavy and Baker,[34] Jones and Pyle,[22] and Arnold[1] to minimize splashing and surging of the liquid over the outlet weir. Care should be taken to avoid augmenting the pressure drop caused by the mounting of baffles.

The establishment of a calming section adjacent to the outlet weir is another means of accomplishing the above object. The unperforated portion of the tray near the outlet weir is usually from 3 to 4 inches wide depending on the flow rate and tower diameter. The following are recommended:

$$\left.\begin{array}{l}\text{When } D \geq 5 \text{ ft., use } w_s = 4 \text{ inches} \\ D < 5 \text{ ft., use } w_s = 3 \text{ inches}\end{array}\right\} \qquad (10)$$

In commercial applications, many engineers prefer the provision of the calming zone rather than mounting a splash baffle.

It is also desirable to establish a calming section at the inlet side immediately before the first row of perforations. The effect of the compact heads can be absorbed in this area. The width of the calming zone at the inlet side is between 3 and 4 inches depending on the liquid flow rate. This writer recommends that the calming zones at both sides be made the same width.

The clearance between the column wall and the nearest hole should be as small as possible to permit maximum utilization of the tray area. However, a clearance of about from 2 to 3 inches is necessary to meet the interference of tray supports.

Finally the area left for perforations can be calculated by:

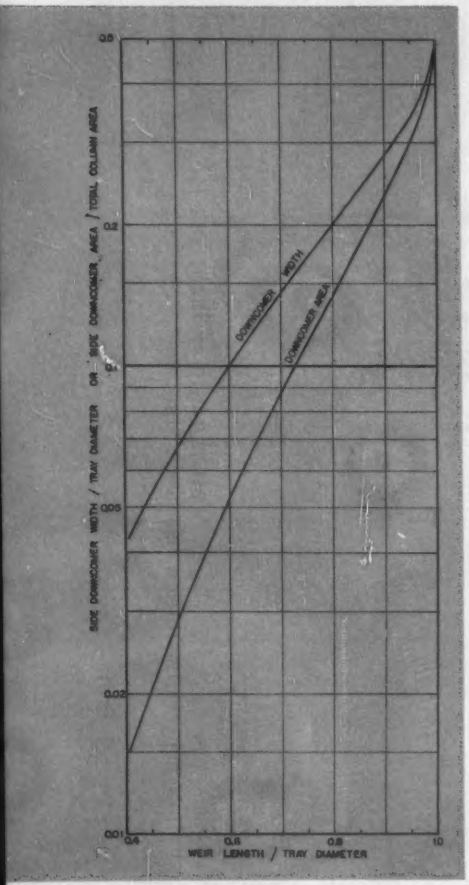

FIGURE 5—The most frequently used weir lengths are within 55 to 85 percent of the tray diameter.

$$A_a = A_t - \Sigma A_d - A_s - A_w \quad (11)$$

Where A_a = Area available for perforations
ΣA_d = Downcomer Areas
A_s = Total Calming Zone Area
A_w = Wall Clearance Area

For a cross-flow type tray, the area left for perforations may be expressed by the following equation:

$$A_a = A_t - 2A_d - A_s - A_w = 2\left(x\sqrt{r^2 - x^2} + r^2 \sin^{-1}\frac{x}{r}\right) \quad (11a)$$

$$\text{Where } x = \frac{D}{2} - \frac{W_d + W_s}{12}$$

$$r = \frac{D}{2} - \frac{W_c}{12}$$

$\text{Sin}^{-1}\frac{x}{r}$ = Arc Sine in radian

Tray Thickness. The plates used in commercial applications should be thick enough to assure sufficient mechanical strength and to provide long life against corrosion. For punched trays of copper alloy or carbon steel, the tray should not be thicker than the hole diameter and the limit for a stainless tray is ½ to ⅔ of the hole diameter. A correlation of vapor pressure drop through the perforation shows that the tray thickness is not a variable if the ratio of tray thickness to hole diameter is equal to 0.9 or greater.[10,19]

Perforations—Size and Spacing. The perforations in a tray should be carefully drilled or punched to the specified diameter. The most popular hole sizes in industrial applications are 3/32, ⅛ and 3/16 inch diameter. Both Arnold[1] and Hunt[19] observed the fact that the stability is not markedly different for different hole sizes, although the stability increases with the decreasing hole diameter. From visual observation of the apparent vapor-liquid contacting efficiency, Mayfield et al.[32] concluded that the smaller holes would be more efficient. At a constant ratio of total hole area to vapor flow area below the tray, Nandi and Karim[33] reported that the tray efficiency increases as the hole diameter decreases.

Hunt's vapor pressure drop correlation was not based on the hole size but on the ratio of the perforation area to the vapor flow area below the plate. For thin plates, however, Arnold[1] observed that the pressure drop increases with an increasing hole diameter at a constant vapor flow rate and at a constant ratio of perforation area to the column cross-sectional area for vapor flow. The entrainment study of Hunt and coworkers[19] has shown that the entrainment from ½ inch holes is exceptionally higher than that from other hole sizes. The tendency of vapor jetting through the liquid in the case of ¼-inch holes was found by Mayfield.[32] According to Friend and Lemieux[14] the majority of Kellogg-designed trays had 3/32-inch holes. The reason for this preference was not given. But they stated that the hole size generally does not limit the flexibility of operation in properly designed trays. Mayfield[32] recommended 3/16-inch holes. With ⅛-inch holes, the drilled tray is more expensive than the punched tray. In trays with small holes, a small error in the hole diameter in drilling or punching will introduce a greater effect on the pressure drop, percentagewise. The hole sizes recommended here as standards are 3/32, ⅛ and 3/16-inch.

Hole spacing may be specified by n, the ratio of hole pitch to hole diameter. Equilateral triangular pitch seems to be the most popular in practice. When the holes are spaced very close to each other, an interaction between the vapor streams flowing through the adjacent holes may occur.[1] This reduces the contacting area between vapor and liquid. According to Hunt[19] the tray would be unstable for general use if hole spacing, n, is equal to 2 or smaller. The recommended range of n is

$$2.5 \leqslant n \leqslant 4.0 \quad (12)$$

The total perforation area can be calculated from the geometry of hole spacing and the hole diameter. For holes spaced with equilateral triangular pitch, the following equation may be used to obtain the total perforation area:

$$\frac{A_o}{A_a} = \frac{\frac{\pi}{4} d_o^2}{(n\,d_o)\,(d_o \sin 60°)} = \frac{0.9065}{n^2} \quad (13)$$

The ratios for several values of n have been computed and are reported in Table 1.

TABLE 1
Perforation Area Ratio

n	A_o/A_a
2.5	0.1450
3.0	0.1007
3.5	0.0740
4.0	0.0566
4.5	0.0447

Liquid Gradient. The hydraulic gradient is the driving force which causes the liquid to flow across the tray. Mayfield et al.[32] obsedved that the hydraulic gradient across a tray of 6.5 feet diameter was negligible. Arnold[1] reported the same for smaller trays. Therefore in determining the liquid build-up in the downcomer, the contribution of the hydraulic gradient is omitted.

Dry-Plate Pressure Drop. The vapor pressure drop due to vapor flow through the perforations has been studied extensively.[1,19,32] An orifice equation has been used to correlate the pressure-drop through the dry-plate. For trays with a single hole, Claypool[10] reported that the tray thickness is not a variable in the pressure drop correlation if the ratio of the tray thickness to the hole diameter, t/d_o, is 0.9 or greater. For thin plates, the effect of the tray thick-

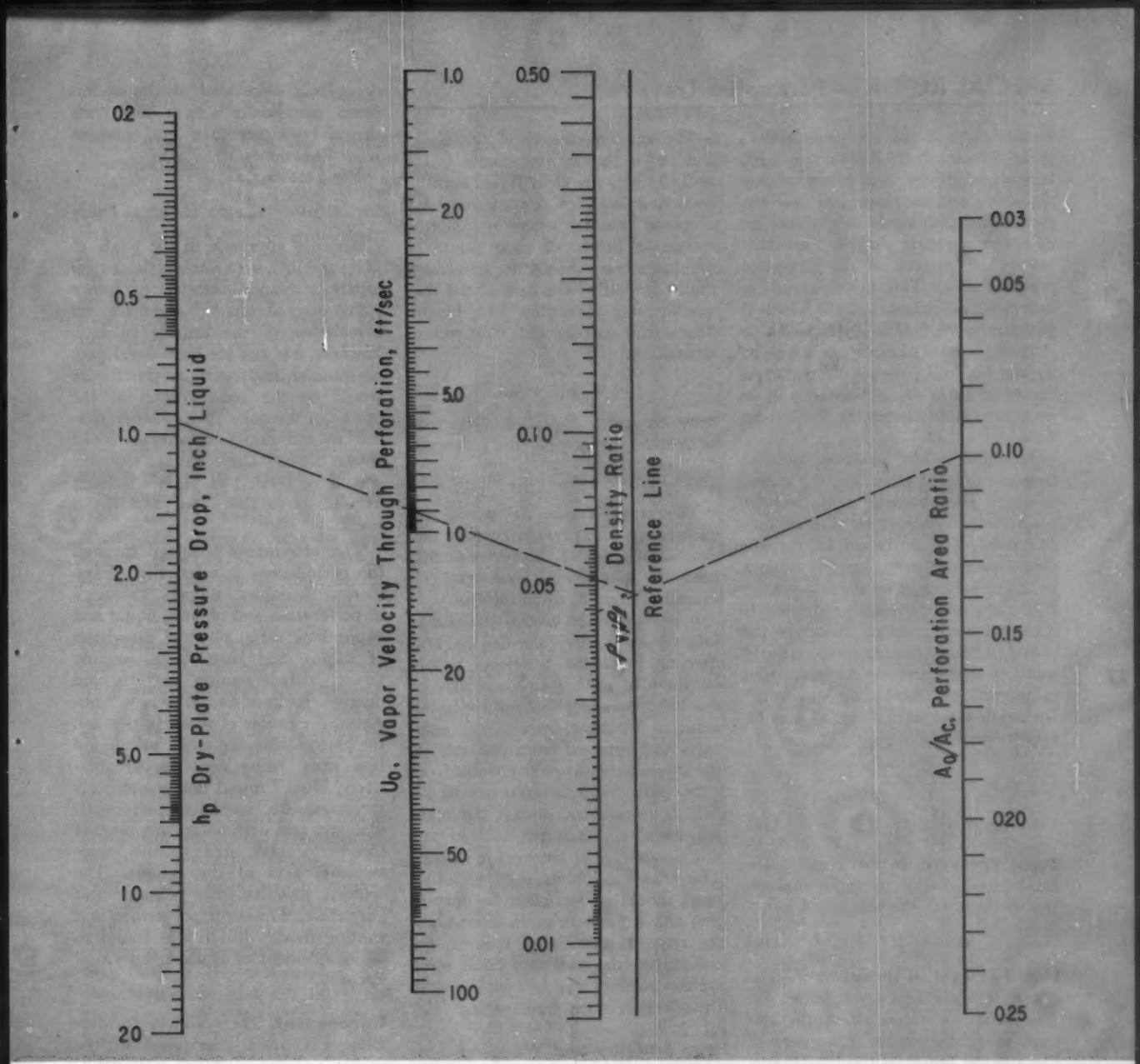

FIGURE 6—The calculation of the dry plate pressure drop is another determination which is easier with the aid of a nomograph.

ness has been recognized for some time.[1,23,30] For multiple-hole plates, Hunt[19] correlated the dry-plate pressure drop by the following equation where $t/d_o = 1$.

$$h_p = (12)\left(\frac{\rho_V}{\rho_L}\right)(1.14)\left(\frac{u_o^2}{2g_c}\right)\left[0.4\left(1.25-\frac{A_o}{A_c}\right)+\left(1-\frac{A_o}{A_c}\right)^2\right] \quad (14)$$

Figure 6 is useful for the solution of Equation (14). For the derivation of the equation, the pressure drop was interpreted as the sum of an entrance loss and an exit loss through the perforation. The perforations are sharp-edged both at the entrance and exit. For industrial application, trays are usually thick to provide strength and longer freedom from the effect of corrosion. Therefore, Equation (14) may be used without a significant error unless t/d_o is very small. Equation (14) can correlate the experimental data reported by other workers[1,32] within 30 percent error. It should be pointed out here that the precision of the hole diameter was important in experimentation. A small deviation in the hole diameter changes the vapor pressure drop appreciably. The data for different gases were successfully correlated by this equation. Equation (14) was derived for a circularly symmetric sudden enlargement and contraction of the flow area. But it is believed to be applicable for most commercial trays where the symmetry is not always realized.

Residual Pressure Drop. Experimental evidences have been reported to show that the total pressure drop is not simply the sum of the clear

liquid height on the tray and the dry-plate pressure drop. Arnold[1] reported that the observed total pressure drop through a wet tray is greater than the sum of the clear liquid height and the dry-plate pressure drop by approximately 10 percent of the dry-plate pressure drop. This unaccounted-for pressure loss has been called "Residual pressure drop." One explanation is that the amount of energy represented by the residual pressure drop is consumed to form vapor bubbles and to generate turbulence in the frothed-up liquid.[1,19]

Mayfield et al.[32] observed residual pressure drop of from 0 to 0.2 inches of water. Hunt's work[19] confirmed the magnitudes reported by Arnold and Mayfield. The variation of the residual pressure drop due to changes in the liquid height on the tray, vapor flow rate, and physical properties, is a complicated problem. Since the residual pressure drop is comparatively small, a small error in its estimation is insignificant. According to Hunt,[19] the residual pressure drop, h_r, may be approximated by

$$h_r = 0.5\left(\frac{\rho_{water}}{\rho_L}\right) = \frac{31.2}{\rho_L} \qquad (15)$$

Total Pressure Drop. Finally, the total pressure drop of vapor through the wet tray may be calculated by:

$$h_t = h_l + h_p + h_r \qquad (16)$$

Liquid Height in Downcomer. The control of the liquid height in the downcomer is important as the column would be flooded if the level of the aerated liquid in the downcomer reaches the top of the outlet weir. The liquid height in the downcomer in terms of clear liquid can be calculated by:

$$h_B = h_l + h_t + h_d \qquad (17)$$

In order to prevent flooding even at the anticipated maximum loading, both the anticipated maximum vapor and liquid loads should be used to obtain h_l, h_t, and h_d. An estimation of the exact frothed liquid height in the downcomer requires a reliable value of the average density of the frothed liquid. As discussed before, the degree of aeration cannot be estimated with accuracy at the present time.

The average density of the liquid and vapor in the downcomer is 0.4 to 0.75 times the clear liquid density. Several writers,[4,28] therefore, have proposed that for a safe design, the maximum height of clear liquid in the downcomer should not be greater than one half of the sum of the tray spacing and the outlet weir height. This writer concurs with their recommendation.

$$h_B \leqq \tfrac{1}{2}(S + h_w) \qquad (18)$$

Tray Spacing. Equation (18) may be rearranged to yield the following:

$$S \geqslant 2h_B - h_w \qquad (19)$$

The trays should be spaced far enough apart to prevent flooding and excess entrainment. More frequently used tray spacings in commercial columns are from 12 to 36 inches.

Bolles[4] discussed several mechanical factors which may decide the tray spacing. Sufficient manways should be provided so that any tray may be reached by passing through the maximum of 10 other trays if the manways are removed from one side. If the tray manways are removable from either side, the maximum can be 20.

It is recommended that the manway be about 20 inches wide to permit the passage of an average worker. The tray spacing between all other trays should be sufficient for inspection and repair works. In some cases, the required number of trays in the column or the available head room for the column may be controlling in the selection of the tray spacing.

Tray Stability and Weeping. One of the criticisms of the perforated tray is that the range of stable operations is narrow. For a given height of clear liquid on the tray, there is a corresponding minimum vapor velocity below which the tray begins to "weep." Mayfield et al.[32] determined the weep point by careful observation. The clear liquid depths on the tray at the weep points were related to the observed dry-plate pressure drop. Based on Mayfield's observation, the following equation is suggested for the minimum dry-plate pressure drop required for stable operation.

$$h_{pw} = 0.2 + 0.05\,h_l \qquad (20)$$

To insure the stable operation of the tray, the dry-plate vapor pressure drop, h_{pm}, calculated at the anticipated minimum vapor flow rate should be larger than h_{pw} obtained from Equation (20).

For a stable tray,

$$h_{pm} \geqq h_{pw} \qquad (21)$$

Another approach to the study of plate stability is to establish a critical minimum vapor velocity to insure stable operations.[1,19] A generalized correlation of the critical velocity, however, has not yet been developed. A sounder approach in the future would be the consideration of the optimum weepage in a manner similar to the optimum entrainment shown before. The optimum weepage should be related to plate efficiency as well as to the vapor and liquid loads.

The amount of weepage through the perforations is a function of numerous variables, namely geometry of perforation and of weir, liquid and vapor flow rates, physical properties of vapor and liquid, i.e. wetting power, surface tension, viscosity and density. Johnson and Lavergne[29] observed the profile of weepage through the perforations, the vapor and liquid flow rates, being variables. Qualitatively, Hunt[18] found that the stability increases with decreasing perforation diameter and with decreasing ratio of the perforation area to the cross-sectional area of the column. The stability also increases with greater gas density, liquid surface tension and wetting power. But it was found to be independent of liquid density and viscosity.

Entrainment. The optimum entrainment has been discussed in the previous section on "Process Requirements." The entrainment from a well-designed tray should not exceed the optimum value specified in the process requirements sheet. This criterion is based on the belief that the effect of entrainment is confined to a plate efficiency function only and that its contribution to the clear liquid height is negligible.

The results of an extensive study on entrainment have been reported by Hunt and co-workers.[19] Entrainment was observed to be independent of the vapor velocity through the perforations but to be proportional to an exponential function of the column vapor velocity divided by the effective tray spacing.

$$e = 0.22\left(\frac{73}{\sigma}\right)\left(\frac{u_c}{S_e}\right)^{3.2} \qquad (22)$$

This equation may be solved graphically on Figure 7.

The effective tray spacing is defined as the distance between the surface of the froth and the plate above. Assuming that the average density of the frothed liquid on the tray is 0.4 times the clear liquid density, the effective tray spacing is readily calculated by:

$$S_e = S - 2.5\,h_l \qquad (23)$$

The correlation of Hunt and coworkers[19] is applicable for different vapors and liquids. The entrainment from a perforated tray is lower than that from a bubble-cap tray at the same column vapor velocity and effective tray spacing. In most commercial perforated tray columns, flooding occurs before the entrainment reaches the optimum value.

Tray Efficiency. Very little information on plate efficiency for commercial perforated tray columns has been reported. The important variables are the physical properties (density, viscosity, diffusivity, surface tension, etc.) of both vapor and liquid phases, geometry of tray layout, and operating conditions. A quantitative discussion is not attempted here since the available information is meager.

The recent work on liquid phase efficiency by Gerster et al.[15] indicated that the tray efficiency depends on the column vapor velocity rather than that through the perforations. The contacting time and the interfacial area between phases control the mass transfer rates through the liquid phase.

The study of Umholtz and Van Winkle[41] for a small perforated column (1.02-inch diameter) showed that the plate efficiency increased, and then decreased to essentially a constant value as the vapor flow rate was increased. It appears, then, that there must be an optimum vapor velocity which gives the maximum plate efficiency. They did not succeed in establishing effects of physical properties on the plate efficiency.

Nandi and Karim[32] also reported the existence of maximum plate efficiency at a certain range of vapor flow rates. An increase in tray spacing and a decrease in hole diameter also increased the plate efficiency.

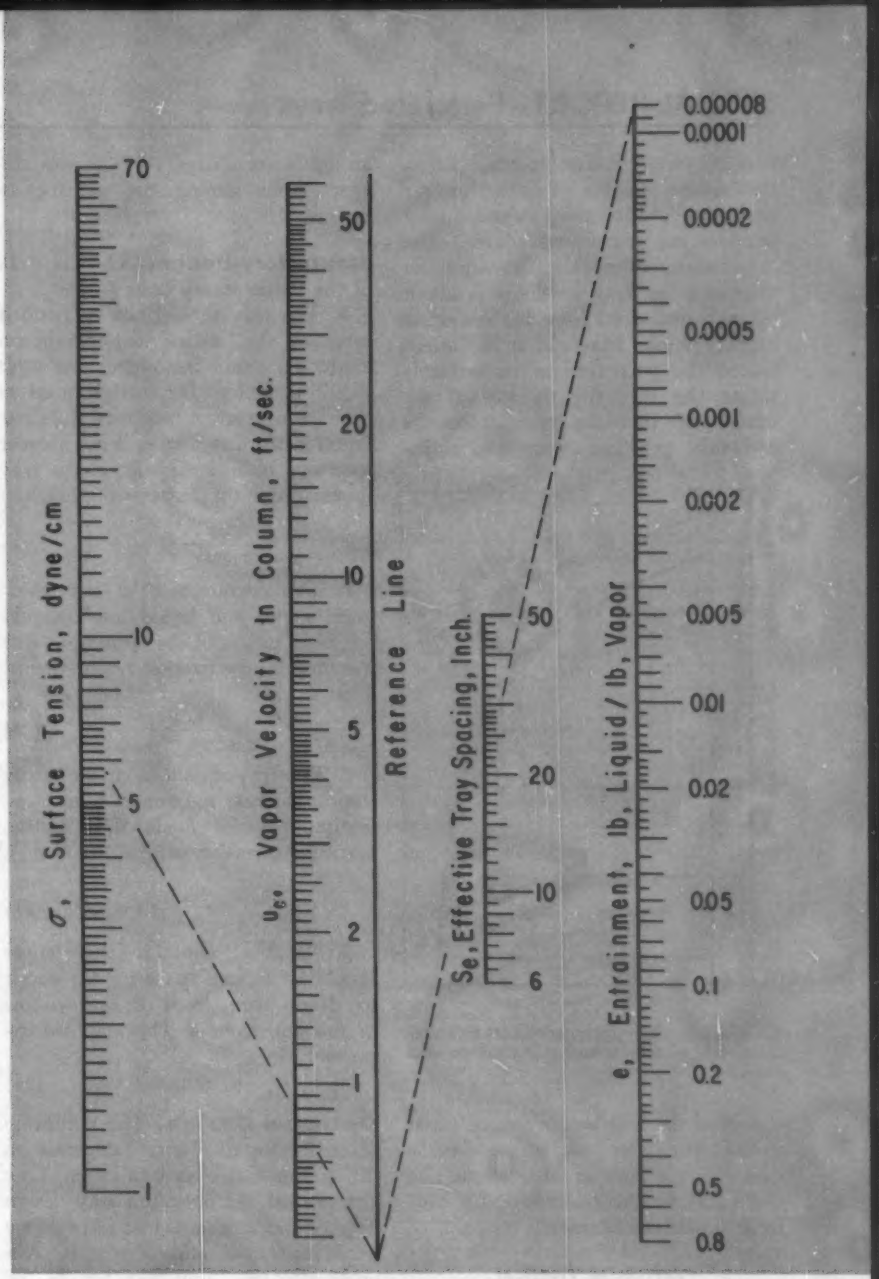

FIGURE 7—Entrainment has been observed to be independent of the vapor velocity through the perforations.

Vapor Disengagement in Downcomer. In order to provide a pathway for disengaging vapor, Davies[12] and Bolles[4] recommended the following limitation:

$$w_l \leq 0.6\,w_d \qquad (24)$$

where W_l and W_d represent the maximum throw of liquid over the weir, and the downcomer width, respectively. Bolles presented an equation to calculate the liquid throw over the weir:

$$w_l = 0.8\sqrt{h_{ow}\,(S + h_w - h_R)} \qquad (25)$$

The minimum residence time of the liquid downflow in the downcomer was recommended to be 5 seconds by Bolles. Otherwise, not all the entrained vapor in this downflow can disengage.

Tray Deflection and Levelness. Trays should be perfectly leveled. An inclination of the tray produces an uneven liquid height and pressure drop across the tray. The entrainment collected on the tray above increases with tray inclination. These ill-effects, in turn, contribute to a maldistribu-

tion of vapor. Excessive tray deflection under weights of both the tray and liquid, also, may cause similar troubles as mentioned above. The maximum allowable deflection or tolerance for tray levelness is about ⅛ inch measured from the lowest to highest points. Mayfield et al.[32] mentioned the practice of deliberately tilting the tray slightly toward the outlet weir in order to minimize the hydraulic gradient effects and to insure that the tray would not be tilted toward the inlet side due to workmanship tolerance in fabrication. The weirs should also be leveled for uniform liquid distribution.

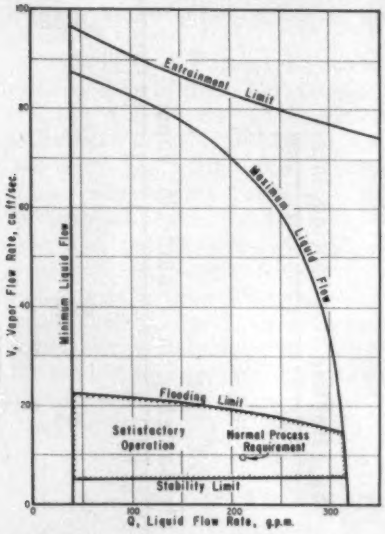

FIGURE 8—A performance chart indicates the limits of satisfactory performance of a tray.

OPTIMUM DESIGN

Designers of the perforated tray have a wide latitude in their choice of each of the design variables, the tray diameter, tray type, tray spacing, weir length and height, perforation diameter, spacing and so on. A tray layout is made by combining these variables, and the possible combinations are numerous. An exhaustive study should be made of all the possible combinations in order to eliminate any tray layout which is unsatisfactory from the tray dynamics point of view. Designs of trays which perform satisfactorily judged by tray dynamic calculations are called, in this article, *satisfactory designs*. A process engineer would be requested further to select an *optimum design* or optimum designs from among the satisfactory designs.

Satisfactory Designs. The criteria of the "satisfactory design" are:

a. The tray should not be flooded even at the anticipated maximum loads. To attain this object, the trays should be spaced far enough apart so that the maximum height of the clear liquid in the downcomer is not greater than one half of the sum of the tray spacing and the outlet weir height.

$$\frac{h_B}{S+h_w} \leqq \frac{1}{2} \qquad (18)$$

b. The entrainment at the maximum vapor and liquid loads should not be in excess of the optimum value specified by the process requirements. That is

$$\frac{e_o}{e} \geqq 1 \qquad (26)$$

c. The tray should be stable under the anticipated maximum liquid and minimum vapor loads. The mathematical expression of this criterion is:

$$\frac{h_{pm}}{h_{pw}} \geqq 1 \qquad (21)$$

d. Another point is that there should be enough space for the vapor to disengage from the downflow in the downcomer. This may be expressed as

$$w_l \leqq 0.6\, w_d \qquad (24)$$

Optimum Design. The definition of an "optimum design" depends on the circumstance and situation. One criterion of the optimum tray design may be the attainment of satisfactory performance at minimum cost. Another situation may demand, as the criterion, flexibility for a wide range of operational loads. Or, a combination of both may be required:

a. *Construction Cost*

Cast iron, sheet carbon steel, and sheet metal of various alloys have been used for construction of perforated trays. Sheet metal is specified more often than cast iron since it is lighter and cheaper. A column with sheet metal trays does not require a heavy foundation and tower structure. Low carbon steel is the usual material for non-corrosive service. Other metals and alloys may have to be specified if the condition of corrosion so demands. If perforations are to be punched, the material and tray thickness should also be selected from the point of view of the punching process. For a comparison of construction costs, the relative tray costs are presented by Bolles.[4]

For the comparison of costs, the total tower cost should be considered, and not the cost of a single tray only. Plate efficiency must be considered in order to determine the actual number of trays in the column. It is unfortunate that the effect of tray layouts on the tray efficiency cannot be estimated accurately at this time. Due to the difference in loads, different sections of the column may require different tray layouts. Therefore, the total column cost cannot be calculated before the satisfactory tray designs for different sections have been made.

In construction of a colum, the labor costs may be assumed to be approximately the same for different tray layouts of similar diameter. Thus the comparison of construction costs may be reduced to the comparison of construction material cost for the purpose of selection of "optimum design."

For the cross-flow tray, Y, the material cost per unit section which includes one tray, column wall between two trays, and a downcomer wall, can be calculated from the following equation

$$Y = \lambda_1 \frac{S}{12}\pi D + \lambda_2 (A_t - A_d) + \lambda_3 \frac{L_w S}{144} \qquad (27)$$

The above equation shows that the cost is the function of the tray diameter, tray spacing and the weir length. Therefore, the tray of the smallest diameter is not always the cheapest to construct.

b. *Flexibility*

The operating flexibility of the tray is best shown by a performance chart, such as Figure 8. The chart indicates the area of satisfactory performance with respect to vapor and liquid loads. The procedure for construction of performance charts will be described later. The construction of a performance chart for each satisfactory design is not always practical due to time limitations. Therefore, an alternative, an approximation in nature, of comparing the ratios of

$$\frac{h_B}{S+h_w}, \quad \frac{e_o}{e}, \quad \frac{h_{pm}}{h_{pw}}$$

as a measure of flexibility, may prove useful.

EXAMPLE PROBLEM

It is advisable that the process requirements be tabulated similar to Table i, and this will constitute the basis for the design of the tray.

Approximate Diameters. Equations (2) and (3) are used to determine approximate diameters corresponding to the respective tray spacings of 12, 15, 18, 20, 24 and 30 inches.

$$G = K\sqrt{\rho_V(\rho_L - \rho_V)} \qquad (2)$$

Where $\rho_V = 1.53$ lb./cu. ft.
$\rho_L = 33.71$ lb./cu. ft.
$\sigma = 6.9$ dyne/cm.
} (From Table i)

Assuming tray spacing
$S = 24$ in.
$K = 520$ (From Figure 2)

Then $G = 520\sqrt{1.53\ (33.71 - 1.53)}$
$= 3650$ lbs./(hr.) (sq. ft.)

$$D = 1.13\sqrt{\frac{V_M}{G}} \qquad (3)$$

Where $V_M = 53{,}356$ lbs./hr. (From Table i)

Then $D = 1.13\sqrt{53{,}356/3650}$
$= 4.32$ ft. or 4.5 ft.

Equations (2) and (3) should be repeated for tray spacings other than 24 inches shown here. The resulting approximate diameters may be tabulated as in Table ii.

Design Diameters. Tray layouts by combining the various design variables are not attempted for all diameters, but for only two or three. The selection is made by comparing the material cost per unit section of the column. Equation (27) may be used.

$$Y = \lambda_1 \frac{S}{12}\ \pi D + \lambda_2 (A_t - A_d) + \lambda_3 \frac{L_w S}{144}$$

For a rough comparison of cost, the weir length is assumed to be 60 percent of the column diameter. Furthermore, the tray may be assumed to be cross flow type. Then $L_w = 7.2D$.

$$A_d = 0.05\ A_t \text{ (From Figure 5)}$$

Unit prices of material cost per square foot are as shown in Table i:

$\lambda_1 = \$2.80$
$\lambda_2 = \$0.79$
$\lambda_3 = \$0.50$

$$Y = (2.80)\frac{S}{12}\ \pi D + 0.79\ (1 - 0.05)\ A_t + \frac{(0.50)\ (7.2)\ DS}{144}$$
$$= 0.7351\ SD + 0.747\ A_t$$

Assuming tray spacing
$S = 24$ in.
$D = 4.5$ ft.

Then $Y = (0.7351)\ (24)\ (4.5) + (0.747)\ (0.785)\ (4.5)^2$
$= 91.26$ \$/unit section

Similar calculations for other tray spacings are made and the results are tabulated in Table ii. Three design diameters, 4.5, 5.0 and 5.5 feet may be selected since their corresponding material cost are the smallest.

Maximum and Minimum Vapor and Liquid Loads. Liquid and vapor loads are calculated for normal, maximum and minimum operating capacities.

If the range of maximum and minimum loads are not given in the specification sheet, the suggestion in the section entitled "Process Requirements" may be used as a guide for determination of those loads.

The average of the three best design diameters is 5 feet. Therefore (100 ± 30) percent of the normal loads may be used for the maximum and minimum loads.

Normal Operation:

$$V = \frac{V_M}{(3600)\ (\rho_V)}$$
$$= \frac{53{,}356}{(3600)\ (1.53)}$$
$$= 9.69 \text{ cu. ft./sec.}$$
$$Q = \frac{L_M\ (7.48)}{(60)\ (\rho_L)}$$
$$= \frac{(57{,}510)\ (7.48)}{(60)\ (33.71)}$$
$$= 212.7 \text{ gal./min.}$$

Maximum Loads
$V_{max} = (9.69)\ (1.30) = 12.59$ cu. ft./sec.
$Q_{max} = (212.7)\ (1.30) = 276.5$ gal./min.

Minimum Loads
$V_{min} = (9.69)\ (0.70) = 6.78$ cu. ft./sec.
$Q_{min} = (212.7)\ (0.70) = 148.9$ gal./min.

Tray Types. Figure 3 is used as a guide for selecting the tray type. At $Q = 212.7$ gal./min. and $D = 4.5$ feet the liquid flow pattern on the tray may be "cross flow."

Weir Lengths and Liquid Heights Over Weir. For demonstration of the proposed procedure, layouts only for one particular diameter, 4.5 feet, will be shown in this illustration. The same

TABLE I
Process Requirements

Item No. F-301	Service: Splitter
Tray No. 20	Date: 12/5/56

PROCESS REQUIREMENTS

Operating Pressure, psia		170
Operating Temperature, °F		180
Molal Liquid-Vapor Ratio		1.08
Assumed Dry Plate Efficiency, Percent		80
Total Theoretical Plates Required		50
Optimum Entrainment, lbs. entrainment/lb. vapor		0.10
Material Cost	Column Wall (λ_1), — \$/sq. ft.	2.80
	Tray (λ_2), — \$/sq. ft.	0.79
	Downcomer Wall (λ_3), — \$/sq. ft.	0.50

		Vapor Phase	Liquid Phase
Material		Hydrocarbons	Hydrocarbons
Molecular Weight			
Density, lb./cu. ft.		1.53	33.71
Liquid Surface Tension, dyne/cm.			6.90
Normal Load	Lb. moles/hr.		
	Lb./hr.	53,356	57,510
	Gpm		
	Cu. ft./sec.		
Minimum Load	Lb. moles/hr.		
	Lb./hr.		
	Gpm		
	Cu. ft./sec.		
Remarks:			

TABLE II
Comparison of Approximate Column Diameters

Tray Spacing, Inches	Approximate Diameter, Ft.	Material Cost \$/Unit Section
12	7.0	90.5
15	5.5	78.4
18	5.0	80.8
20	4.5	78.0
24	4.5	91.3
30	4.0	97.6

procedure, of course, should be applied for layouts with other diameters.

The most frequently used weir lengths are within 55 to 85 percent of the tray diameter.

Equation (5) or Figure 4 may be used to calculate h_{ow}.

The results of L_w specified and h_{ow} calculated are tabulated for the tray with 4.5 feet diameter in Table iii.

Liquid heights over weir, $(h_{ow})_{max}$ and $(h_{ow})_{min}$, are calculated for the anticipated maximum and minimum liquid loads respectively.

Outlet Weir Heights:

$$h_{w\,max} = 4.0 - h_{ow} \qquad (4)$$

Where $1.5 \leq h_w \leq 3.5$

Selections are tabulated in Table iii. Weir heights may be selected with increments of ¼ instead of ½ inch.

Inlet Weir Heights. Inlet weir is not specified here.

Clear Liquid Height. Clear liquid heights may be calculated by Equation (7). The anticipated maximum h_{ow} should be used for the equation.

For illustrative purposes, a tray diameter of 4.5 feet with 37.8-inch weir length will be used.

$$h_l = h_w + h_{ow}$$

$$h_l = 1.5 + 1.82 = 3.32 \text{ in. } (h_w = 1.5 \text{ in.})$$

$$h_l = 2.0 + 1.82 = 3.82 \text{ in. } (h_w = 2.0 \text{ in.})$$

Downcomer Clearance:

$$h_w - h_c = \tfrac{1}{2} \text{ or } \tfrac{1}{4} \qquad (8)$$

$h_w - h_c = 0.25$ is used here.

Liquid Head Loss in Downcomer:

$$h_d = 0.03\left(\frac{Q}{100\,A_p}\right)^2 \qquad (9)$$

The allowable maximum h_d is about 1 inch liquid.

$$A_{dc} = \frac{(1.25)\ (37.8)}{144} = 0.328 \text{ sq. ft., } (h_w = 1.5 \text{ in.})$$

$$A_{dc} = \frac{(1.75)\ (37.8)}{144} = 0.459 \text{ sq. ft., } (h_w = 2.0 \text{ in.})$$

$A_d = 0.087\ A_t$ (From Figure 5)

$$A_t = \frac{\pi}{4}(4.5)^2 = 15.9 \text{ sq. ft.}$$

$A_d = 1.38$ sq. ft.

When A_{dc} is substituted for A_p, Equation (9) yields:

$h_d = 1.7$ in. > 1.0 (at $h_w = 1.5$ in.)

$h_d = 1.0$ in. (at $h_w = 2.0$ in.)

TABLE III
Weir Length and Liquid Height Over Weir
D = 4.5 ft.

$L_w / 12_D$	0.55	0.60		0.65		0.70		0.75		0.80		0.85	
L_w, in	29.7	32.4		35.1		37.8		40.5		43.2		45.9	
(h_{ow}) max	2.20	2.07		1.97		1.82		1.78		1.70		1.64	
(h_{ow}) min	1.48	1.39		1.30		1.25		1.20		1.15		1.10	
H_w, in	1.5	1.5	2.0	1.5	2.0	1.5	2.0	1.5	2.0	1.5	2.0	1.5	2.0

The case of $h_w = 1.5$ in. is not satisfactory and this choice is eliminated.

Area Available for Vapor Flow in Column.

$$A_e = A_t - A_d$$
$$A_e = 15.9 - 1.4 = 14.5 \text{ sq. ft.}$$

Available Area for Perforation. In cross-flow type tray:

$$A_a = 2\left[\, x\sqrt{r^2 - x^2} + r^2 \sin^{-1}\frac{x}{r}\,\right] \qquad (7)$$

$$\text{where } x = \frac{D}{2} - \frac{w_d + w_s}{12}$$

$$r = \frac{D}{2} - \frac{w_c}{12}$$

$$w_s = = 3 \text{ in.} \qquad (10)$$
$$w_c = = 3 \text{ in.}$$
$$w_d = = (12D)\ (0.1425) = (12)\ (4.5)\ (0.1425) = 7.7 \text{ in.}$$
$$x = \frac{D}{2} - \frac{7.7 + 3}{12} = 1.35 \text{ ft.}$$
$$r = 2.25 - \frac{3}{12} = 2.0 \text{ ft.}$$
$$A_a = 2\left[\, (1.35)\ \sqrt{2.0^2 - 1.35^2} + 4\ \mathrm{Sin}^{-1}\frac{1.35}{2}\,\right] = 9.90 \text{ sq. ft.}$$

Hole Diameter and Tray Thickness. See discussion.

$d_o = \tfrac{1}{8}$ in.
$t = \tfrac{5}{16}$ in.

Total Hole Area. If equilateral triangular pitch is chosen, the total hole area may be obtained by Equation (13). The ratio of hole pitch to hole diameter, n, should be specified within the limits of Equation (12).

When $n = 2.5$

$$\frac{A_o}{A_a} = 0.1450 \quad \text{(From Table 1)}$$

$$A_o = \left(\frac{A_o}{A_a}\right)(A_a) = (0.1450)\ (9.90) = 1.436 \text{ sq. ft.}$$

A_o corresponding to other values of n are tabulated in Table iv.

Vapor Pressure Drop—*a. Dry Plate Pressure Drop.*

Dry-plate pressure drop can be calculated by Equation (14) or Figure 6. Example is shown for $n = 2.5$.

$$\frac{A_o}{A_a} = \frac{1.436}{14.51} = 0.099$$

$$u_o = \frac{V_{max}}{A_o} = \frac{12.59}{1.436} = 8.78 \text{ ft./sec.}$$

$$\frac{\rho_V}{\rho_L} = \frac{1.53}{33.71} = 0.0453$$

$h_p = 0.93$ in. liquid (From Figure 6)

b. Residual Pressure Drop.

For all tray layouts in this problem, the residual pressure drop may be calculated as follows:

$$h_r = \frac{31.2}{\rho_L} \qquad (15)$$
$$= \frac{31.2}{33.71}$$
$$= 0.94 \text{ in. liquid.}$$

c. Total Pressure Drop.

$$h_t = h_p + h_r + h_l \quad (16)$$

$h_t = 0.93 + 0.94 + 3.82$
$= 5.69$ in. liquid

Height of Liquid Build-Up in Downcomer:

$$h_B = h_l + h_t + h_d \quad (17)$$

$h_B = 3.82 + 5.69 + 1.00$
$= 10.51$ in.

Tray Spacings. Trays should be spaced far enough apart to avoid flooding.

$$S \geqq 2h_B - h_{ow} \quad (19)$$

$S \geqq (2)\ (10.51) - 2$
$S \geqq 19.02$
$\therefore S \geqq 20$ in.

Tray Stability. Tray stability should be examined at maximum liquid and minimum vapor loads. Tray may be stable if the following conditions are satisfied.

$$h_{pm} \geqq h_{pw} \quad (21)$$

$$\text{where } h_{pw} = 0.2 + 0.05\ h_l \quad (20)$$

$h_l = 3.82$ in. at maximum liquid load
$h_{pw} = 0.2 + 0.05\ (3.82)$
$= 0.39$ in. liquid

$$u_o \text{ min} = \frac{V_{min}}{A_o} = \frac{6.78}{1.436} = 4.72 \text{ ft./sec.}$$

$h_{pm} = 0.34$ in. (From Figure 6)

Since $h_{pm} < h_{pw}$, the tray with $n = 2.5$, is unstable and it will be eliminated.

Entrainment:

$$e = 0.22 \left(\frac{73}{\sigma}\right)\left(\frac{u_c}{S_o}\right)^{3.2} \quad (22)$$

$$S_o = S - 2.5\ h_l \quad (23)$$

$$u_c = \frac{V_{max}}{A_c}$$

Entrainment calculated by Equation (22) should not be more than e_o indicated in "Process Requirements" section (see Equation 1). If e is more than e_o, the tray is not satisfactory because of excessive entrainment.

$$u_c = \frac{V_{max}}{A_c} = 0.868 \text{ ft./sec.}$$

$S_o = 30 - 2.5\ (3.82)$ $(n = 3.5)$
$= 30 - 9.55$
$= 20.45$ in.

$e = 0.95 \times 10^{-4}$ lbs. liq./lb. vapor (From Figure 7)

TABLE iv—Perforated Tray Design Calculation

Tray No.	20	D, ft.	4.5	d_o, in.	½	W_p, in	3	r, ft.	2.0	h_r, in. liq.	0.93
Tray Type	Cross Flow	A_t, Sq. ft.	15.90	t, in.	3/16	W_c, in	3	P_v/P_L	0.0453		

DESIGN NUMBER	1	2	3	4	5	6	7	8	9	10	11 → 20
$L_w/12D$										0.70	
L_w in.										37.8	
(h_{ow}) max, in. liq.										1.82	
(h_{ow}) min, in. liq.										1.25	
(h_w) out in.			1.5					2.0			
(h_w) in in.			—					—			
h_l, in.			3.32					3.82			
h_c, in.			1.25					1.75			
A_{do} sq. ft.			0.328					0.459			
A_d sq. ft.										1.38	
A_a sq. ft.										14.51	
h_d in. liq.			1.70					1.00			
A_h sq. ft.										9.90	
n						2.5	3.0	3.5	4.0	4.5	
A_o sq. ft.						1.436	0.997	0.733	0.560	0.443	
A_o/A_c						0.099	0.069	0.051	0.039	0.031	
(U_o) max ft/sec						8.78	12.63	17.18	22.48	28.42	
h_p in. liq.						0.93	2.01	3.90	7.00	11.50	
h_t in. liq.						5.69	6.74	8.67	11.76	16.26	
h_B in.						10.51	11.59	13.48	16.58	21.08	
S in.						20.00	24.00	30.00	36.00	40.00	
h_{pw} in. liq.								0.39			
(U_o) min ft/sec						4.72	6.80	9.25	12.11	15.30	
h_{pm} in. liq.						0.34	0.58	1.01	1.97	3.30	
U_c ft/sec										0.868	
S_o in.						—	14.45	20.29	26.27	30.29	
e lb. liq./lb. vap.							1.9×10^{-4}	0.95×10^{-4}	0.42×10^{-4}	0.16×10^{-4}	
0.6 W_d, in.										4.63	
W_l, in.							4.10	4.63	4.99	5.48	
Y, $/unit sect							93.74	111.31	—	—	
$H_B/(S + h_w)$							0.446	0.421			
h_{pm}/h_{pw}							1.49	2.59			

Vapor Disengagement in Downcomer:

$$W_1 = 0.8 \sqrt{h_{ow} (S + h_w - h_B)} \qquad (25)$$

A good tray design requires that W_1 should be smaller than $0.6\ W_d$.

$$n = 3.0$$
$$W_1 = 0.8 \sqrt{1.82\ (24 + 2 - 11.59)}$$
$$W_1 = 4.10 \text{ in.}$$
$$0.6\ W_d = 0.6 \times 7.72 = 4.63 \text{ in.}$$
$$W_1 < 0.6\ W_d$$

As shown in Table iv, the tray layouts with $n = 4.0$ and $n = 4.5$ are not satisfactory because $W_1 > 0.6\ W_d$.

Material Cost. Construction material costs should be estimated for each tray layout so that the optimum tray designs may be selected on this basis.

$$Y = \lambda_1 \frac{S}{12} \pi D + \lambda_2 (A_t - A_d) + \lambda_3 \frac{L_w S}{144} \qquad (27)$$

$$n = 3.0$$
$$Y = \frac{(2.80)\ (3.14)\ (24)\ (4.5)}{12} + (0.79)\ (14.51) + \frac{(0.50)\ (37.8)\ (24)}{144}$$
$$= 93.74 \text{ dollars/unit section.}$$

Flexibility. As the basis for comparison of the degree close to flooding and stability, the following ratios are calculated.

$$\text{At } n = 3.0$$
$$\frac{h_B}{S + h_w} = 0.446$$
$$\frac{h_{pm}}{h_{pw}} = 1.49$$

Optimum Designs. The above procedures may be repeated for other combinations of column diameter and weir length to select satisfactory layouts and to eliminate unsatisfactory ones.

Optimum designs shall be selected from among the satisfactory layouts by inspecting construction costs, and

$$\frac{h_B}{S + h_w} \text{ and } \frac{h_{pm}}{h_{pw}} \text{ ratios.}$$

For the given process requirements, the repetition of the above procedures reveals that there are 38 satisfactory tray layouts.

Among these 38 satisfactory tray layouts, 4 tray designs are selected as optimum. Final choice of the tray design for construction should be made after consideration of the over-all column costs.

TABLE v
Perforated Tray Specification

Tower No.
Tray No.
Specified by
Date

A) MATERIAL OF CONSTRUCTION:
1) Tray
2) Downcomer

B) TYPE OF TRAY:

C) TRAY DATA:
1) Hole Diameter: "
2) Hole Spacing "
3) Total Hole Area sq. ft.
4) No. Holes
5) Thickness "
6) Spacing "

D) DOWNCOMER DATA:
1) **Side:**
a) Weir Length "
b) Downcomer Width "
c) Downcomer Area sq. ft.
d) Downcomer Volume cu. ft.
e) Clearance to Tray "
2) **Center:**
a) Weir Length "
b) Downcomer Width "
c) Downcomer Area sq. ft.
d) Downcomer Volume cu. ft.
e) Clearance to Tray "

E) WEIR DATA:
1) **Side:**
a) Height "
b) Thickness "
2) **Center:**
a) Height "
b) Thickness "
3) **Adjustable:** (Yes) (No)
a) Range + To − " from median.

F) GENERAL:
1) **Column I.D.**
2) **Distribution Baffles**
a) Location
b) Clearance
c) Height
3) **Tolerances**
a) Weir: ± "
b) Tray: ± "
c) Spacing: ± "

G) FREE TRAY AREA:
1) 1) Inlet weir to edge first row holes: "
2) Outlet weir to edge last row holes: "
3) Inside tower wall to hole edge: "

N.B. Tray layout sketch attached.

Performance Curves. For a selected tray design or designs, performance curves should be prepared for further information concerning the range of satisfactory operation. The preparation of such curves is discussed more completely in a later section.

Specification Sheet. For the selected tray design, finally, the specification sheet similar to Table v should be prepared.

PERFORMANCE CHART

The performance chart indicates the limits of satisfactory performance of a tray. The following operating limits constitute the boundaries of satisfactory operation and are usually included in a performance chart. The preparation of a performance chart for tray design No. 7 is illustrated as follows:

Minimum Liquid Load Limited by Minimum Liquid Height over Weir. To provide good liquid distribution on the tray, the liquid over weir should be maintained at least 0.5 inch high. Then the minimum liquid flow rate to produce this liquid height may be calculated by

$$Q = 2.98\ L_w\ (0.5)^{3/2} \qquad (10)$$

$$L_w = 37.8 \text{ in.}$$
$$Q = 2.98\ (37.8)\ (0.5)^{3/2}$$
$$= 39.8 \text{ gal./min.}$$

The contribution of entrainment from the tray below is neglected here. The vertical line of $Q = 39.8$ in Figure 8 represents the operating limit of minimum liquid load.

Maximum Liquid and Vapor Loads Limited by Maximum Clear Liquid Height on Tray. The maximum liquid height on the tray is about 4 inches. This criterion, in turn, limits the maximum liquid height over weir according to the following equation.

$$h_{ow\ max} = 4.0 - h_w \qquad (4)$$

$$h_w = 2.0 \text{ in.}$$
$$\therefore h_{ow\ max} = 4.0 - 2.0$$
$$= 2.0 \text{ in.}$$

Then, the liquid load to provide this $h_{ow\ max}$ may be calculated by

$$Q_{max} = (2.98)\ (L_w)\ (h_{ow})_{max}^{3/2}$$
$$= (2.98)\ (37.8)\ (2)^{3/2}$$
$$= 318.6 \text{ gal./min.}$$

To establish each performance curve, the limiting vapor flow rates, V_1 cu.ft./sec., corresponding to six or

seven different Q_l values should be calculated. For simplification of later calculations, it is more convenient to begin by choosing seven different $(h_{ow})_i$ values between 0.5 and $(4.0 - h_w)$ using the following equation:

$$(h_{ow})_i = 0.5 + \left[\frac{(4.0 - h_w) - 0.5}{6}\right] i$$
$$= 0.5 + \left[\frac{(4.0 - 2.0) - 0.5}{6}\right] i$$
$$= 0.5 + 0.25\,i$$

Where i are integers between 0 and 6. Then the second row of Table 2 may be completed.

The Q_l values determined by Figure 4 corresponding to each h_{ow} value are tabulated in the third row of Table 2.

The maximum liquid load calculated above, at $h_{ow} = 4.0 - h_w$ is based on the assumption that the contribution of entrainment to the clear liquid height on the tray is negligible. But the assumption is no longer valid at high vapor flow rates, and the contribution of entrainment from the tray below should be taken into consideration.[19] Therefore, at a net liquid flow rate, Q_l, there should be a sufficiently high vapor flow rate, V_l which produces enough entrainment to make the clear liquid height on the tray equal to 4.0 inches. The equation to calculate V_l corresponding to a net Q_l is:

$$(0.22)\left(\frac{73}{\sigma}\right)\left(\frac{V_l}{A_c} \cdot \frac{1}{S_c}\right)^{3.2} (V_l \rho_V) = (\Delta Q_l)\,(0.1338)\frac{1}{60}(\rho_L)$$

$$V_l^{4.2} = (1.39 \times 10^{-4})\,(\Delta Q_l)\,(\sigma)\,(A_c)^{2.2}\,(S - 10)^{2.2}\,\frac{\rho_L}{\rho_V}$$

where $\Delta Q_l = Q_s - Q_l$
$\sigma = 6.9$ dyne/cm.
$(A_c)^{2.2} = (14.51)^{2.2} = 5216$
$(S - 10)^{2.2} = (24 - 10)^{2.2} = 4652$
$\rho_L/\rho_V = 22.075$

Then

$$V_l^{4.2} = 513{,}720\,[\Delta Q_l]$$

At i = 5
$\Delta Q_l = 56.0$ gal./min.
$V_l = 60.15$ cu. ft./sec.

Individual V_l values calculated by this equation are tabulated in the fourth row of Table 2.

The plot of V_l vs Q_l for this limitation as shown in Figure 8 is generally somewhere above the flooding limiting curve.

Maximum Vapor Flow Rate Limited by Flooding. a. To avoid flooding of the tray:

$$h_B \leqq \tfrac{1}{2}\,(S + h_w) \qquad (18)$$

$S = 24$ in.
$h_w = 2$ in.
$h_B \leqq \tfrac{1}{2}\,(24 + 2)$
$\leqq 13$

b. Substitution of h_B value obtained by Equation (18) into Equation (16) yields

$$h_p = h_B - 2h_l - h_r - h_d$$

where the right hand side is the function of only the liquid flow rate, Q_l, for a particular tray design and vapor-liquid system.

At i = 5
$Q_s = 260.8$ gal./min.
$h_d = 0.98$ in.
$h_r = 0.93$ in.
$h_l = 3.75$ in.
$\therefore h_p = 13 - (2)\,(3.75) - (0.93) - (0.98)$
$= 3.59$ in.
$A_o/A_c = 0.069$
$\rho_V/\rho_L = 0.0453$

c. The calculated dry-plate pressure drop is finally substituted into Equation (14), or Figure 6 is used, to determine the maximum allowable vapor flow rate from the standpoint of flooding.

At i = 5
$h_p = 3.59$ in.
$u_o = 17.5$ ft./sec. From Figure 6

Then $V_s = (u_o A_o) = 17.50 \times 0.997$
$= 17.45$ cu. ft./sec.

The fifth row of Table 2 is a tabulation of the limiting vapor flow rates for flooding corresponding to each liquid flow rate.

Maximum Vapor Flow Rate Limited by Excessive Entrainment. The amount of entrainment to the tray above should not be more than the optimum value specified by the process requirement.

a. For each liquid flow rate, the corresponding clear liquid height on the tray, and the effective tray spacing may be calculated.

At i = 5
$h_l = 2 + 1.75 = 3.75$ in.
$S_e = S - 2.5\,h_l$
$= 24 - 2.5\,(3.75)$
$= 14.625$ in.

b. The substitution of S_e and σ into Equation (22) results in the upper limit of vapor flow rate beyond which the amount of entrainment to the tray above exceeds the optimum value.

$$V_l = 0.42\,(e_o\sigma)^{\frac{1}{2.2}}\,(A_c)\,(S_e) \qquad (22)$$

$\sigma = 6.9$ dyne/cm.
$e_o = 0.1$ lb. liq./lb. vap.

$$(e_o\sigma)^{\frac{1}{2.2}} = (0.69)^{\frac{1}{2.2}} = 0.8905$$

At i = 5
$V_l = (0.42)\,(0.8905)\,(14.51)\,S_e$
$= 5.427\,S_e$
$= (5.427\ 14.625)$
$= 79.37$ cu. ft./sec.

Figure 7 may be used for determining V_l.

Minimum Vapor Flow Rate Limited by Stable Operation. The tray is stable if the dry-plate pressure drop is larger than that calculated by Equation (20).

a. For the liquid flow rate of Q_l, the corresponding liquid height on the tray has been determined above. Then, using Equation (20) the minimum dry-plate pressure drop required for stable operation may be calculated.

At i = 5
$h_l = 3.75$ in. liq.
$h_{pw} = 0.3875$ in. liq.

TABLE 2—Performance of Tray No. 7

i	0	1	2	3	4	5	6	Remarks
h_{ow}, in.	0.50	0.75	1.00	1.25	1.50	1.75	2.00	
Q, g.p.m.	39.8	73.1	112.6	157.5	206.9	260.8	318.6	
V, cu. ft./sec.	87.48	84.86	81.40	76.77	70.35	60.15	0	Maximum Clear Liquid Height Limitation
V, cu. ft./sec.	22.53	22.22	21.33	19.94	18.54	17.45	14.06	Flooding
V, cu. ft./sec.	96.33	92.94	89.55	86.15	82.76	79.37	75.98	Excessive Entrainment
V, cu. ft./sec.	5.08	5.18	5.28	5.38	5.48	5.58	5.68	Stable Operation
V, cu. ft./sec.	0	0	0	0	0	0	0	Vapor Disengagement

b. The dry-plate pressure drop is then substituted in Equation (14), or Figure 6 is used, to obtain the corresponding minimum vapor flow rate.

From Figure 6

$$u_o = 5.6 \text{ ft./sec.}$$
$$V_1 = (u_o)(A_o)$$
$$= (5.6)(0.997)$$
$$= 5.58 \text{ cu. ft./sec.}$$

Minimum Vapor Flow Limited by Vapor Disengagement. a. The maximum liquid throw over weir, w_1, is limited to 0.6 w_d so that there is sufficient pathway for disengaging vapor.

$$w_d = 7.78 \text{ in.}$$
$$w_1 = 0.6\, w_d$$
$$= 4.70 \text{ in.}$$
$$h_w = 2.0 \text{ in.}$$
$$S = 24.0 \text{ in.}$$
$$h_B = 26 - \frac{34.516}{h_{ow}}$$

b. For a chosen liquid flow rate, there is a corresponding minimum h_B calculated by Equation (25).

$$h_B = S + h_w - \left(\frac{w_1}{0.8}\right)^2 \frac{1}{h_{ow}}$$

At $i = 5$

$$h_B = 26 - 19.72$$
$$= 6.28 \text{ in.}$$

c. The limiting minimum vapor flow rate, then, may be determined according to the same procedure as outlined in b and of the "flooding section."

At $i = 5$,

$$h_p = 3.59 \text{ in.}$$

From Figure 6, u_o is obtained as 17.50 ft./sec.

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NOMENCLATURE

A_a — Area available for perforation, sq. ft. ($= A_t - 2A_d - A_s - A_w$)
A_c — Column cross-sectional area available for vapor flow, sq. ft.
A_d — Downcomer area, sq. ft.
A_{dc} — Downcomer clearance area, sq. ft.
A_m — Construction material area, sq. ft.
A_p — Area in Cicalese's Equation (16), A_d or A_{dc} whichever is smaller.
A_s — Total calming zone area, sq. ft.
A_t — Column cross-sectional area, sq. ft.
A_w — Wall clearance area, sq. ft.
D — Column diameter, ft.
d_o — Hole diameter, in.
E — Dry plate efficiency
e_o — Optimum entrainment, lbs. liquid per lb. vapor
e — Entrainment, lbs. liquid per lb. vapor
G — Maximum allowable vapor mass velocity calculated by Brown and Souder's Equation, lbs./(hr) (sq. ft.)
g_c — Conversion factor, 32.2 lbl./lbf.
h_B — Height of clear liquid build-up in downcomer, in.
h_c — Downcomer clearance, in.
h_l — Clear liquid height on tray, in.
h_{ow} — Liquid height over weir, in.
h_p — Dry-plate pressure drop, in. liquid
h_{pm} — Dry-plate pressure drop at anticipated minimum vapor flow rate, in. liquid
h_{pw} — Minimum dry-plate pressure drop required for stable operation determined by Figure 6, in. liquid
h_r — Residual pressure drop, in. liquid
h_t — Total pressure drop through a tray, in. liquid
h_w — Weir height, in.
K — Constant in Equation (2) determined by Figure 1.
L_M — Liquid flow rate, lbs./hr.
L_w — Weir length, in.
n — Ratio of hole pitch to hole diameter
p_o — Hole pitch, center to center, in.
Q — Liquid flow rate, g.p.m.
r — $\left(= \frac{D}{2} - \frac{W_c}{12}\right)$, ft.
S — Tray spacing, in.
S_e — Effective tray spacing, in.
t — Tray thickness, in.
t_d — Thickness of downcomer wall, in.
t_w — Wall thickness, in.
u_c — Column vapor velocity, ft./sec.
u_o — Vapor velocity through holes, ft./sec.
V_c — Volume of construction material, cu. ft.
V — Vapor flow rate, cu. ft./sec.
V_{max} — Anticipated maximum vapor flow rate, cu. ft./sec.
V_{min} — Anticipated minimum vapor flow rate, cu. ft./sec.
V_M — Vapor flow rate, lbs./hr.
w_c — Wall clearance, distance between wall and nearest perforations, in.
w_d — Downcomer width, in.
w_1 — Liquid throw over weir, in.
w_s — Width of calming zone, in.
x — $\frac{D}{2} - \frac{w_d + w_s}{12}$, ft.
Y — Total material cost for unit section, dollars per section. The unit section includes a tray, column wall between two trays, and downcomer walls.
ρ_L — Liquid density, lb./cu. ft.
ρ_V — Vapor density, lb./cu. ft.
σ — Liquid surface tension, dyne/cm.
λ_1 — Unit price of column wall material of t_w inch thickness dollars per sq. ft.
λ_2 — Unit price of tray of t inch thickness, dollars per sq. ft.
λ_3 — Unit price of downcomer wall of t_d inch thickness, dollars per sq. ft.

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In California: Petrochemical Boom?

This state now accounts for almost 10 percent of all petrochemical production and the outlook for future growth is good.

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Air Products of Florida, West Palm Beach, Fla.

THE IMPORTANCE of the California segment of the petrochemical industry, in terms of raw materials, is compared with the national industry in Table 1. In order to facilitate comparison, the quantities are given in terms of poundage and dollar value.

Data in Table 1 are derived largely from U. S. Tariff Commission. However, the quantities of methane in Table 1 include the amounts used for chemical conversion to carbon black, ammonia and methanol, while the Tariff Commission report "Synthetic Organic Chemicals" lists only a small amount of this. Again, an allowance has been made for duplication of material reported in the C_2, C_3 and C_4 classes. For example, a large amount of the ethylene produced from petroleum is reported first as propane and later as ethylene. Likewise, much of the C_4 classification "butane and butylenes" again appears as butadiene.

Methane used for carbon black overshadows the other uses, but very little carbon black is produced in the West from this source. Consequently, by comparison, the western utilization of C_1 is small. Likewise, the utilization of C_2 hydrocarbons in the West is small in comparison with the total. The reason for this is that many of the important ethylene derivatives are not yet made in the West. Going down toward the bottom of the barrel, as the refiner would say, the utilization of the C_3, C_4, aromatics, and other petroleum raw materials is more in proportion to the western need for the derived chemicals, and with the California industry in general. The West is an important supplier of petroleum coke.

Methane and Natural Gas. California produces only synthetic ammonia with its by-product carbon dioxide and the chlorinated methanes with by-product hydrogen chloride from natural gas.

Ammonia: The first petrochemical plant in California to use natural gas was the Shell synthetic ammonia plant at Pittsburgh. In fact, this was the first plant to use natural gas as a hydrogen source. Carbon black appears as a by-product. The plant was completed in 1931 and has been expanded several times. A number of other producers have followed in the production of ammonia from natural gas or refinery gas until there are now four producers with five plants. These are listed in Table 2.

In addition to the plants listed, there is a small production of petroleum by-product ammonia at the Union refinery at Wilmington and the General Petroleum refinery at Torrance. This is recovered as the sulfate.

Total ammonia capacity in the state from all sources is approximately 400,000 tons per year. The largest use, that of agriculture, is about 250,000 tons per year. Industrial uses amount to about 15 percent of the total.

Carbon Dioxide: In California, by-product carbon dioxide from ammonia manufacture is sold as liquid CO_2 and as dry ice. At Ventura a portion of the production goes into Shell's manufacture of a fertilizer material—urea. National production of carbon dioxide is 825,000 tons per year, while the California production is about 95,000 tons per year. Most of this comes from the above ammonia plants, but there is some production at fermentation alcohol plants and from straight burning of fuel oil or gas. Recovery of carbon

TABLE 1
Petrochemical Raw Materials in the U. S. Compared to California

Raw Materials	National Billions Lbs.	California Millions Lbs.	National Value in Millions $
C_1—Methane, Nat Gas	15	440[1]	25[2]
C_2—Ethane, Ethylene, Acetylene	4	180	150
C_3—Propane, Propylene, and Polymers	2.5	430	25
C_4—Butane, Butylene, Butadiene and Polymers	3.5	350	185
Aromatic Hydrocarbons	3.5[3]	500[3]	130
All other Hydrocarbons Cresylic Acid, Naphthenic Acid	1.0[4]	50[4]	35
Sulfur and H_2S	1.0	350	12
Petroleum Coke for Chemical and Metallurgical Use	3.0	1,100	18
	33.5 Billion	3.39 Billion	580

[1] Includes requirement for five ammonia plants
[2] Approximate value
[3] Includes aromatic type solvents
[4] Excluding petroleum thinners

TABLE 2
California Ammonia Plants Producing from Petroleum Sources

Company	Location	Date of Production	Current Capacity Tons/Day
Shell Chemical Corp	Pittsburg	1931	330
Shell Chemical Corp	Ventura	1953	150
Hercules Powder Co	Pinole	1940	100
Collier Carbon and Chemical Corp.	Brea	1954	275
Standard Oil Co of California	Richmond	1956	300
			1,155

dioxide at natural gas wells in California has now been discontinued.

Chlorinated Methanes: The only organic chemicals of any importance produced from methane or natural gas in California are the chlorinated methane derivatives; methyl chloride, methylene chloride, chloroform, and carbon tetrachloride. These were first produced in 1935 by a process pioneered by the Great Western Electrochemical Co. Original capacity of the plant was 10 million pounds per year of chlorinated products, but since merging with Dow Chemical Co. in 1939 the chlorination plant has been enlarged. Annual production of chlorinated products by this process is about 450 million pounds in the United States today.

In California there is no utilization of ethane for chemical manufacture. Acetylene is produced in one demonstration unit in Maywood. This plant is operated by Wulff Process Co. and has a capacity of one million pounds per year. The product acetylene is bottled and sold to the welding trade. This plant has been in operation since 1952 and has used a variety of feedstocks.

Ethylene: The third and most important C_2 hydrocarbon is ethylene. In California ethylene was first utilized for production of ethyl benzene at the Torrance rubber facility owned by the U. S. Government. This plant, placed in operation in 1942, was operated by the Dow Chemical Co. and used the Dow process for conversion of ethyl benzene to styrene. The original styrene production was at the rate of about 50-55 million pounds per year of styrene which required 20 million pounds per year of ethylene. This was made by dehydrating ethyl alcohol. Two years later, the rubber facility was doubled and a cracking plant was installed to make 40 million pounds per year of ethylene from propane.

Located adjacent to the ethylene unit is an ethylene dibromide plant with a capacity of roughly two million pounds per year. This was built by the Eston Chemical Co. which is now owned by American Potash & Chemical Co. The ethylene dibromide is used largely as a soil fumigant.

The second producing unit for ethylene in California is the Union Carbide plant in Torrance, started in 1956. This plant utilized the C_2 stream from the General Petroleum Refinery. It separates the preformed ethylene and cracks the residual material to give a total ethylene production of about 140 million pounds per year. This quantity is used for the production of 60 million pounds per year of conventional or high pressure polyethylene, plus 10 million gallons per year of ethylene glycol. Polyethylene is used largely for the manufacture of packaging film, pipe, household articles, and toys. The principal western use for ethylene glycol is for permanent antifreeze.

Isopropyl Alcohol: In California the initial chemical production from propylene was in 1930 at Martinez. In that year, the Shell Chemical Corporation started the production of isopropyl alcohol. A few years later (1935) a second plant was constructed by Shell at Dominguez.

Perchloroethylene: In 1937 the Great Western Electrochemical Co. developed their process for making perchloroethylene and carbon tetrachloride from propane. Later, during the war, Dow Chemical Co., who acquired Great Western, converted a portion of the perchloroethylene to hexachloroethane for military uses.

Propylene Polymer: The utilization of propylene polymer for the manufacture of detergent material is a postwar development. The Standard Oil Co. of California, in 1946, produced detergent alkylate or dodecyl benzene from benzene and the propylene tetramer. This C_{12} polypropylene fraction is recovered from the bottoms of the distillation of polypropylene motor fuel. Dodecyl benzene is reacted with sulfuric acid and then neutralized with caustic to produce the detergent with the fancy name of sodium dodecylbenzenesulfonate. Oronite Chemical Co., the chemical subsidiary formed in 1943, marketed both the detergent alkylate and the sulfonated product. A number of California plants likewise sulfonate and process the material to make detergents. These include the Procter and Gamble, Colgate, and Purex plants, with captive production, and Pilot California of Los Nietos, who started operation in 1953 and merchant their product. Oronite is the largest marketer of detergent alkylate in the world. Total U. S. production of this commodity is 400 million pounds per year, a large portion of which is produced in California.

The C_4 Hydrocarbons

This group includes normal and isobutane, normal and isobutylene and butadiene.

Butyl Alcohol: The initial utilization of C_4 fraction in California was by the Shell Chemical Corp. in 1932. In this year, Shell started production of secondary butyl alcohol at Martinez. Later, a larger plant for the production of secondary butyl alcohol was built at Dominguez. The principal product from this alcohol is a solvent, methyl ethyl ketone. Tertiary butyl alcohol is also produced at Martinez from isobutylene, but the demand for this is much smaller than for the secondary butyl alcohol.

Alkylated Phenols: Further production by Shell Chemical Corp. includes alkylated phenols made by alkylating phenol and cresol with isobutylene or butylene polymers. These alkyl phenols are used in the production of motor oil additives and as oxidation inhibitors for fats, waxes, and oil. Another Shell product made from isobutylene is ditertiary butyl peroxide used as a catalyst for resin polymerization.

Polybutene: Standard Oil Co. of California started their chemical production or products based on C_4 with the manufacture of polybutene in 1943. This is used in adhesives, mastics, synthetic oils and for certain dielectric applications. Production amounts to about 8 million pounds per year.

Synthetic Rubber: The important western petrochemical development of World War II was the synthetic rubber plant at Torrance. Most important raw materials for this plant are the C_4 hydrocarbons which are

converted to butadiene. The product made is SBR rubber.

The rubber facility was constructed for the Rubber Reserve in 1942 and 1953 and represents the most completely integrated of the synthetic rubber plants in the country. While it now depends on C_4 hydrocarbons for the butadiene manufacture, much of the original butadiene came from cracking of naphtha at a plant operated by the Southern California Gas Co.

Also integrated with the Torrance rubber plant was a butadiene unit at El Segundo, operated by the Standard Oil Co. of California. At one time this plant recovered and purified butadiene but later this unit was connected by pipeline to the Shell plant which received the cracked product and separated the butadiene.

The rubber facilities were acquired by Shell Chemical Corporation in 1955 and are now operated by Shell.

The original capacity of the rubber plant was 45,000 long tons per year (100 million pounds per year). This was later almost doubled. Shell initiated an expansion program and the current capacity of the plant is estimated at 110,000 long tons per year (240 million pounds per year) of a broad range of rubber types.

Hydrocarbons C_6+ — Cyclohexane. The C_5 hydrocarbons are not used for chemical conversion in California but cyclohexane, a C_6 nonaromatic hydrocarbon has been of some importance in western chemical production. This material is present in straight run gasolines and has been recovered by the Richfield Oil Corp. by distillation processes. Richfield produced cyclohexane for a period of two years—1951 and 1952. Production amounted to about 30 or 35 million pounds per year which is roughly 10 percent of the national demand. Shell Oil Co. at Dominguez has been a producer of cyclohexane. This is isomerized from methylcyclopentane and recovered by distillation. All the cyclohexane produced in the West has been shipped to eastern manufacturers of synthetic fibers. The cyclohexane is oxidized to adipic acid which is an intermediate in the manufacture of nylon.

Aromatics: Petroleum benzene, toluene and xylene produced for nonfuel use in California amounts to about 250 million pounds per year. A like quantity of aromatic type solvents are produced at California refineries.

In the post war period Standard Oil Company of California has been the principal producer, while Union, Shell, Richfield, and Tidewater have been important sources of the aromatic types.

Benzene has been in short supply for many years in the California-Nevada area and imports have arrived from Utah, Colorado, Oregon, Hawaii, and other points. The supply situation will be greatly improved when Richfield enters the market with an additional 100 million pounds per year of petroleum benzene.

Sulfonates: The first line of aromatic derived products made by Standard Oil Company of California were petroleum sulfonates. These were produced starting in 1920 and were a by-product from the manufacture of white oil, or medicinal oil. By 1945 the demand for highly purified sulfonates prompted Standard to start production. Other producers have more recently appeared. These include the U. B. Bray Company of Alhambra and the Universal Detergents Company in Long Beach.

Phthalic Anhydride: The next venture into the aromatics products by Standard was the separation and conversion of orth-xylene to phthalic anhydride. Standard's phthalic plant was placed in operation in 1944 and was the first producer of this chemical from petroleum sources.

Terephthalic Acid: Another of the xylenes, the para-isomer, was purified and marketed by Oronite to eastern producers of synthetic fibers starting in 1950. Paraxylene is converted to terephthalic acid. This, combined with ethylene glycol makes polyester synthetic fibers and film.

Isophthalic Acid: The third of the xylenes, the meta-isomer, which is present in the greatest quantity in petroleum stocks, was next purified by Standard and is used as a source of isophthalic acid. A 50 million pound per year plant for the production of this chemical was placed in operation in 1956. Isophthalic acid finds use mainly in competition with phthalic anhydride in the manufacture of surface coating and synthetic resins. Standard is the first producer.

Phenol: Standard introduced a new process for making phenol which is based on oxidation of cumene or isopropyl benzene. The cumene is made by reacting propylene with benzene. Capacity of the plant was announced at 35 million pounds per year. Shortly after the Standard plant started production, Monsanto Chemical Company constructed 20 million pounds per year phenol plant at Avon based on the sulfonation method.

Chlorinated Aromatics: Other important aromatics derivatives produced in the California-Nevada area include the chlorinated benzene derivatives. Stauffer Chemical Co. after acquiring the chlorine plant at Henderson, Nevada, has been a producer of monochlorobenzene and benzene hexachloride. The monochlorobenzene goes largely into the Montrose Chemical Co. production of DDT which was started at Torrance, Calif. in 1947. Another producer of chlorinated aromatics is the Universal Western Chemical Corp. of Norwalk, manufacturer of ortho and paradichlorobenzene. Chlorinated paraffins are also produced by Universal. This plant has been in operation since 1952.

Miscellaneous Petroleum By-Products. Included in the miscellaneous classification are the non-hydrocarbon components such as hydrogen sulfide, mercaptans, cresylic, and naphthenic acids, petroleum coke, etc. These compounds appear in petroleum, or arise from refinery operations.

Hydrogen sulfide, present in small amounts in petroleum and produced in large quantities in cracking operations is now recovered and converted to useful products. In 1937, Standard Oil Company of California supplied hydrogen sulfide to the General Chemical Company in El Segundo for sulfuric acid manufacture. There are now four sulfuric acid plants in the state using hydrogen sulfide in

this manner. These include the El Segundo plant, a Stauffer Chemical Company plant at Dominguez using H_2S since 1938, the General Chemical Company plant at Richmond, and the Monsanto Chemical Company plant at Avon. Refineries which are not located adjacent to acid plants convert their hydrogen sulfide to sulfur. Hancock Chemical Co., in 1949, started production of elemental sulfur from hydrogen sulfide at the rate of 30 tons per day (10,000 tons per year). This plant has been expanded and now produces over 100 tons per day. Future production is expected to be 200 tons per day within the next few years, while plant capacity is well above this figure.

Other producers of elemental sulfur are the Union Oil Company of California with plants at Wilmington, Oleum, and Santa Maria; and the Wilshire Oil Company with a plant at Norwalk. Sulfur from these plants is supplied in molten form to acid producers, with a minor amount going to carbon disulfide and lime sulfur. Sulfur equivalent of hydrogen sulfide and sulfur recovered in the state is estimated at 150,000 long tons per year. It is anticipated that California will become self-sufficient in sulfur within 4 or 5 years.

Gas odorants, based on mercaptans and other odoriferous sulfur compounds, have been marketed in California since 1927. Standard Oil Company of California, the original producers, are now the most important supplier of these products in the U. S. Union Oil Company of California recovered and marketed methyl and ethyl mercaptan starting in 1945. This product was used to manufacture methionine, one of the essential amino acids. Production at Union was discontinued when synthetic methyl mercaptan was placed on the market.

Cresylic acids are important by-products from the cracking of California crudes. Almost one half of the national production of 32 million pounds per year of petroleum cresylic acid comes from California refineries. Initial production was by Shell Oil Company and Standard Oil Company of California in 1937. Later, Richfield Oil Corp. and the General Petroleum Corp. entered the market but this production has now been discontinued to be taken up by Productol Company who now refine the crude cresylic from a number of refineries in California and from the Midwest.

Naphthenic acids are present in recoverable quantities in many California crudes. Production in the United States is now about 16 million pounds per year with probably about 50 percent of this in California. During the war, naphthenic acids were in great demand for the production of incendiary bombs. Production in California started in 1930 by General Petroleum Corporation followed in 1931 by Standard Oil Company of California. Later, Shell Oil Company, Richfield Oil Corporation, and Union Oil Company of California entered the market. Production by Union has been discontinued.

Petroleum coke has been available in California since the early Dubbs cracking units went into operation. However, this coke was used only for fuel. The utilization of petroleum coke for chemical purposes dates back to 1940 when the Great Lakes Carbon Corp. started a calcining plant in the Harbor area. There are now two producers of calcined coke, Collier Carbon and Chemical Corporation with a plant in the San Jose area, and the Great Lakes Carbon Corporation. Coke for calcining is available from the Union Oil refineries at Oleum and Santa Maria, General Petroleum Corporation refinery at Torrance and from a new fluid coker of the Tidewater Oil Company at Avon. Total production of coke, with the Tidewater plant in operation, is at the rate of about 3500 tons per day (1,200,000 tons per year). Some of this is used in the West for the production of electrodes. Large quantities are exported to eastern and foreign markets for fuel and chemical uses.

The important building blocks produced from California petroleum sources have been enumerated, and the initial or primary products made from these have been listed. No attempt has been made to follow through with final products or consumer items.

Some of the hydrocarbons, such as a portion of the detergent alkanes and all of the cyclohexane and para-xylene are shipped to eastern or foreign markets but much of the California production is converted to chemicals in western plants.

The authors express their gratitude to the California producers of petrochemicals who have been so generous in furnishing information and to the Collier Carbon and Chemical Corporation for permission to publish this study of the western petrochemical industry.

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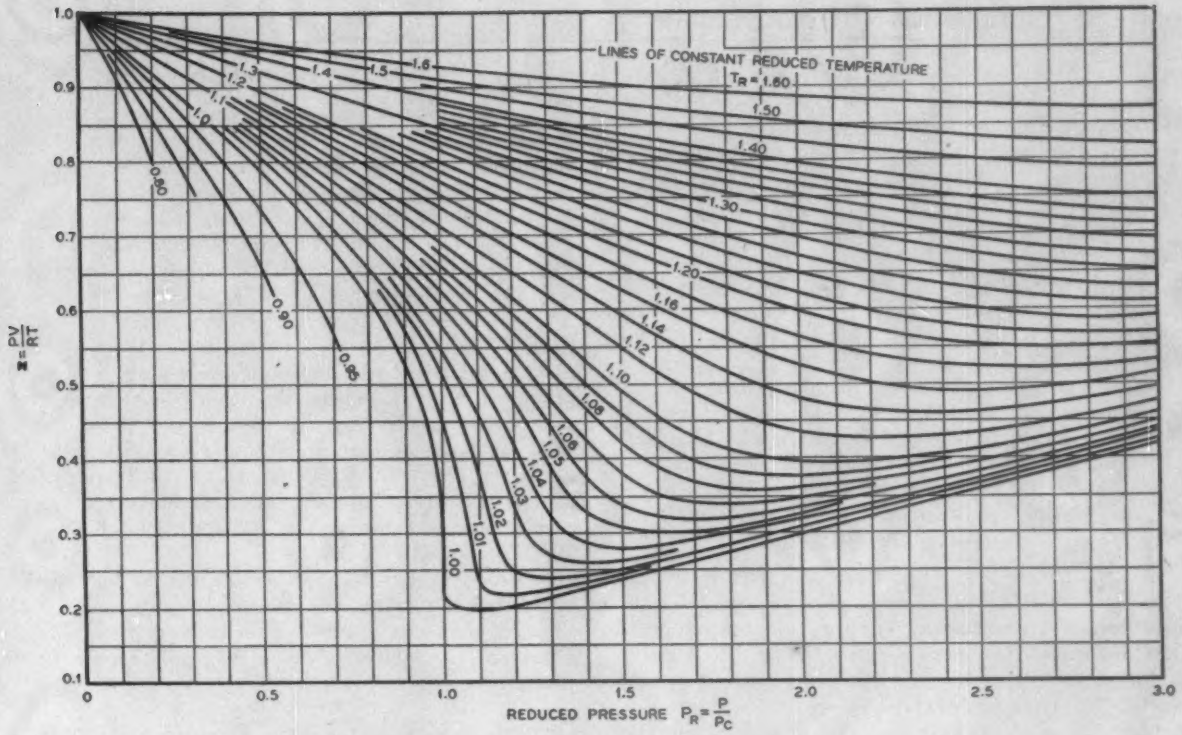

FIGURE 2.1—Generalized compressibility factor chart.

Applied Hydrocarbon Thermodynamics

Part 2—A Review of P-V-T Data Correlations

- Equations-of-state
- Compressibility factors
- Boyle temperature
- P-V-T plots
- Mixture P-V-T
- Partial volumes

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MANY OF THE applications of thermodynamics to hydrocarbon systems that are of interest to process engineers require P-V-T (pressure-volume-temperature) data or correlations. Typical of these are calculating: (1) densities of compressible fluids, (2) the isothermal effects of pressure on enthalpy, entropy, and heat capacity, (3) the fugacity coefficients of the components of mixtures, and (4) partial volumes and enthalpies.

The basic equations used in calculating the effects of pressure on thermodynamic properties from P-V-T data were given in the previous chapter. These equations apply to pure components and mixture, V being volume per mass unit of fluid (pure or mixture). These equations do not apply to the components in the mixtures, however. Fugacity coefficients and partial properties for components of mixtures require P-V-T-C (pressure-volume-temperature-composition) data for computation by thermodynamic methods.

P-V-T data are usually correlated by compressibility factor charts or by equations of state. For many years process engineers have regarded equations of state as chart development tools only and not very practical for problem solving. With the increasing use of computers in engineering work, equations of state become more practical.

The compressibility factor charts use reduced temperature and pressure parameters. Generalized charts of PV/RT versus P_r and T_r are widely used in estimating fluid densities.

Reduced temperature and pressure parameters are also

used in some equations of state. When this general form is used, the constants in the equations are found from the critical properties of the fluid. Usually actual temperature and pressure units are used in equations of state, however. In this case separate empirical constants are used for each substance.

Empirical constants or coefficients for equations of state are obtained by fitting curves to experimental P-V-T data. Various forms of equations are used, depending upon the desired application. A simpler equation may be used for vapor phase calculations than for the liquid.

One of the least exacting equation-of-state applications is defining the P-V-T behavior of the so-called permanent gases, such as air, in compression and flow calculations. Perfect gas law assumption is usually adequate. One of the most exacting equation-of-state applications is in the computation of vapor-liquid equilibria. This involves representing the P-V-T-C data for mixtures. These are the two equations of state extremes that are of interest.

Equation-of-State Forms. The form of an equation of state, for a given application, is first set by the nature of the application and theoretical considerations. Then the coefficients of the equation are found empirically to give the best fit to the P-V-T data. A few general remarks are of interest before looking at the details of the equations.

Following are a few characterizing terms that applied to equations of state:

The virial equation of state is a converging power series of the forms:

$$P = \frac{C_1}{V} + \frac{C_2}{V^2} + \frac{C_3}{V^3} + \frac{C_4}{V^4} + \qquad (2.1)$$

or

$$V = \frac{C_1}{P} + \frac{C'_2}{P^2} + \frac{C'_3}{P^3} + \frac{C'_4}{P^4} + \qquad (2.2)$$

where: $C_1 = RT$ = first virial coefficient
C_2 and C'_2 = second virial coefficient
C_3 and C'_3 = third virial coefficient
C_4 and C'_4 = fourth virial coefficient

All the virial coefficients are functions of temperature. Successive terms become progressively less important.

Equation 2.1 is explicit in pressure, while Equation 2.2 is explicit in volume. The explicity-in-pressure equation is more accurate than an explicity-in-volume equation of the same number of terms.

The density ($d = 1/V$) is sometimes used instead of volume as an equation-of-state variable. Changing from V to 1/d in Equation 2.1 gives

$$P = C_1 d + C_2 d^2 + C_3 d^3 + C_4 d^4 + \qquad (2.3)$$

In this form the equation of state looks simple. As density approaches zero, so does the pressure. The relations for the virial coefficients are complicated functions of temperature, however.

Modifications to the virial form equation of state have been used. One such modification is to replace V with (V-b), where b is a different constant for each substance. Another modification is an exponential temperature term in one of the virial coefficients. The virial form is not altered by the use of this exponential temperature term. An exponential density term is another modification of interest.

Perfect Gas. In 1662, Boyle found that the volume of a simple gas at constant temperature was inversely proportional to the pressure; and in 1801, Charles discovered that the volume of a simple gas at constant pressure was directly proportional to its absolute temperature. Combining these proportionalities for one mole of this same simple gas, gives the so-called "perfect gas" equation, $PV = RT$, where R is the gas constant in the same units as P, V, and T.

Although there are no truly perfect gases, real gases approach the P-V-T behavior defined by this equation under some conditions. This phenomenon is utilized in some methods used in plotting and correlating P-V-T data. The PV product and the ratio PV/RT are plotted against pressure in two correlation techniques. As pressure is decreased toward zero, PV approaches RT, while PV/RT approaches unity.

The perfect gas P-V-T equation may be approached in another way. When all virial coefficients higher than the first are equal to zero, the general equation of state Equation 2.1 reduces to the P-V-T relationship for a perfect gas, i.e.,

$$PV = RT \qquad (2.4)^*$$

On P versus V coordinates, Equation 2.4 defines a family of hyperbolas that exhibit no two phase border curves of critical point. For this reason, Equation 2.4 should only be applied at temperatures well above the critical and at low pressures.

From Equation 2.4, it can be shown that pressure has no effect on the enthalpy of a perfect gas. From Equation 2.4

$$\left(\frac{\partial V}{\partial T}\right)_P = \frac{R}{P} \qquad (2.5)^*$$

Combining with Equation 1.27 gives

$$\left(\frac{\partial H}{\partial P}\right)_T = \left[V - T\frac{R}{P}\right] = 0 \qquad (2.6)^*$$

Combining Equation 2.5 with Equation 1.25 gives the following for entropy

$$\left(\frac{\partial S}{\partial P}\right)_T = -\frac{R}{P} \qquad (2.7)^*$$

Equations 2.6 and 2.7 plus a few other similar expressions define an "ideal gas" state, which is of utility in preparing compilations of thermodynamic properties.

Compressibility Factor. Deviations from the perfect gas law, i.e., Equation 2.4, are frequently expressed in terms of a compressibility factor, z, which is the ratio of the actual gas volume, V, to the perfect gas volume, RT/P. In other words

$$z = \frac{V}{RT/P} = \frac{PV}{RT} \qquad (2.8)$$

The compressibility factor, z, is a function of T and P for each compound. This makes the first temperature derivative at constant pressure (differentiating the product of two variables),

$$\left(\frac{\partial V}{\partial T}\right)_P = \frac{R}{P}\left[z + T\left(\frac{\partial z}{\partial T}\right)_P\right] \qquad (2.9)$$

When the compressibility factor is constant at unity, Equation 2.9 reduces to Equation 2.5.

* Equations identified thus apply only to perfect gases.

Combining with Equations 1.27 and 1.25 gives the following relations for the isothermal effect of pressure on enthalpy and entropy

$$\left(\frac{\partial H}{\partial P}\right)_T = -\frac{RT^2}{P}\left(\frac{\partial z}{\partial T}\right)_P \qquad (2.10)$$

and

$$\left(\frac{\partial S}{\partial P}\right)_T = -\frac{R}{P}\left[z + T\left(\frac{\partial z}{\partial T}\right)_P\right] \qquad (2.11)$$

With precise z factor correlations, pressure effects on thermodynamic properties may be computed by relationships similar to Equations 2.10 and 2.11. z factor correlations are usually graphical so this involves getting graphical derivatives. These calculations are usually generalized by using correlations of z with T_r and P_r, the reduced values of temperature and pressure. Figure 2.1 is a generalized compressibility factor chart. This chart was prepared from hydrocarbon P-V-T data by plotting PV/RT versus P_r for lines of constant T_r. Points for different hydrocarbons fall approximately but not exactly on the same curves.

Because of imperfections in the generalized compressibility factor correlations, such as Figure 2.1, their main utility is in computing fluid densities. They are used occasionally in thermodynamic property derivations but are not the preferred type of P-V-T correlation for this more fundamental application.

Most compressibility factor charts are limited to the vapor phase and do not include the liquid phase or the two phase regions. These regions cannot be covered very accurately on a generalized correlation without a molecule characterizing parameter. This will be brought out later by reference to other charts.

P-V-T Plots. The P-V-T data correlation problem for single and multicomponent mixtures is more clearly evident from the P-V, P-T, and V-T plots in Figure 2.2.

All of these diagrams cover both liquid and vapor phases, as well as the two phase (vapor-liquid) region. The parameter in each case is the remainder of the P-V-T variables. The plots show important differences between single and multicomponent systems. Isobaric vaporization and condensation take place isothermally for pure components. For multicomponent systems, isobaric vaporization takes place with an increase in temperature, while isobaric condensation takes place with a temperature decrease. Likewise, the isothermal vaporization (or condensation) of a multicomponent system takes place with a decrease (or an increase) in pressure.

The general trends in the P-V-T relations in the subcooled liquid and superheated vapor regions are indicated most clearly on the P-V plots. The isochors on the P-T plots are nearly straight lines. The isobars on the V-T plots are curved to a much lesser degree than the isotherms on the P-V plots.

As can be seen by the diagrams in Figure 2.2, the effects of pressure and temperature are more pronounced on gas densities than on liquid densities. For this reason, most correlations are concerned with the vapor phase and analytical correlations (i.e. Equations of State) have been developed from observations made on the volumetric behavior of the gas phase.

Boyle Temperature. For ordinary gases and conditions $PV < RT$ and $(PV/RT) < 1.0$; i.e., z has a value of less than unity. At sufficiently high temperatures these magnitudes reverse, and the temperature at which this reversal occurs is called he Boyle Temperature, T_{Boyle}.

Figure 2.3 illustrates the PV versus P plot for three cases, $T > T_{Boyle}$, $T = T_{Boyle}$, and $T < T_{Boyle}$. At the Boyle point temperature which is believed to occur for all real gases, the product PV is equal to or greater than the RT product at all pressures. At lower temperatures the effect of pressure shown in Figure 2.3 is observed; i.e., the PV product decreases with increasing pressure, goes through a minimum, then increases in value until it crosses the PV = RT line at some high pressure. This is the behavior followed for hydrocarbon and most gases at the temperatures encountered in most industrial operations.

At higher temperatures (the Boyle point is well above atmospheric temperature except for hydrogen and helium, where $T > T_{Boyle}$, the PV product increases with increase in pressure. The Boyle point is of more than theoretical interest because the location relative to T_{Boyle} determines the temperature change upon throttling.

The absolute value of the Boyle temperature is between 3 and 4 times the critical temperature. This is beyond the range of Figure 2.1 and most industrial applications of the generalized compressibility factor chart.

Mixture P-V-T. Densities of mixtures may be estimated in either of two ways: (a) partial volumes (or densities) and (b) equivalent single component compressibility factor. Partial volumes are functions of pressure, temperature, and composition for each component. The compressibility factor for mixtures may be found from the z plots by using the pseudo-reduced temperature and pressure of the mixture.

Before partial volume data and the pseudo-reduced concept became available, it was customary to use two simple laws in computing densities of vapor mixtures. These are: "Dalton's Law of Additive Pressures" and Amagat's Law of Additive Volumes."

Dalton's Law states that the partial pressure of each component of a mixture is equal to the pressure that component would exert if it alone occupied the entire volume. The total pressure is then the sum of these partial pressures. In terms of compressibility factor, z

$$P = \overline{P}_A + \overline{P}_B + \ldots = \frac{z_A N_A RT}{V} + \frac{z_B N_B RT}{V} + \ldots = \frac{z_{mix} N_{total} RT}{V} \qquad (2.12)$$

From the above it follows for Dalton's Law of additive pressures that:

$$z_{mix} = x_A z_A + x_B z_B + \ldots = \Sigma x_i z_i$$

Where z_A, z_B, etc. are evaluated at the values T and V for the system.

Amagat's Law states that the total volume occupied by a gaseous mixture is equal to the sum of volumes that each component would occupy at the temperature and pressure of the system. In terms of compressibility factor, z:

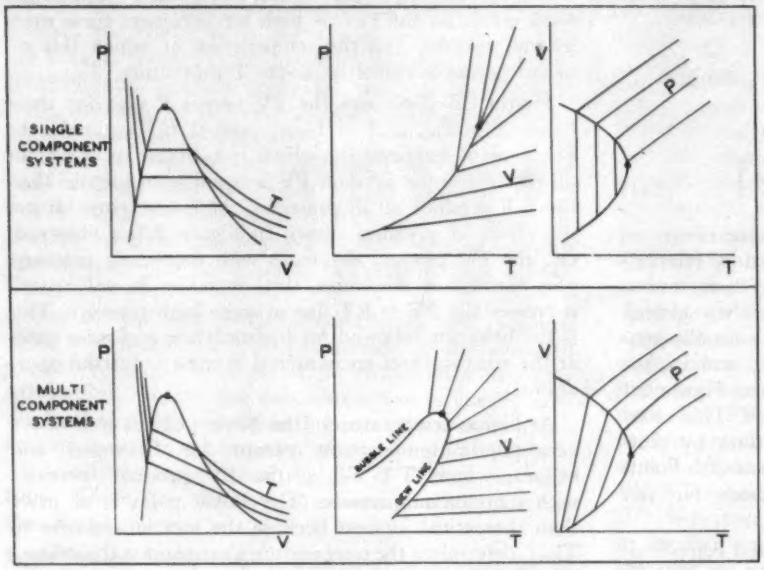


FIGURE 2.2—Types of P-V-T plots for single component and multicomponent systems.

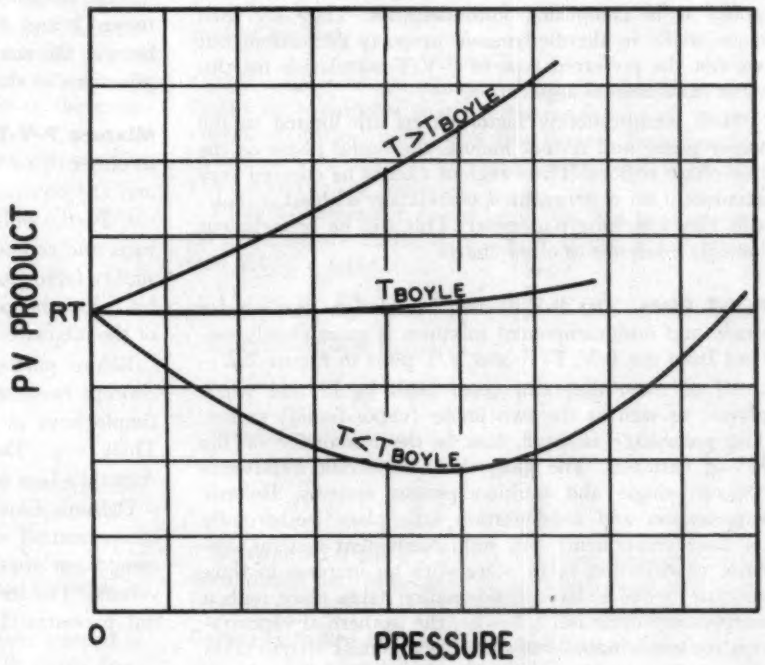


FIGURE 2.3—The relation of temperature and Boyle temperature.

$$V = x_A V_A + x_B V_B + \ldots = \frac{x_A Z_A RT}{P} + \frac{x_B Z_B RT}{P} + \ldots = \frac{z_{mix} RT}{P} \quad (2.13)$$

From the above it follows for Amagat's Law of additive volumes that:

$$z_{mix} = x_A Z_A + x_B Z_B + \ldots = \Sigma x_i Z_i$$

Where z_A, z_B, etc. are evaluated at the values of T and P for the system.

A widely accepted method for predicting mixture P-V-T data is to apply the generalized compressibility factor chart, such as Figure 2.1, to mixtures by the pseudo-reduced conditions, defined as follows:

$$T_{pr} = \frac{T}{T_{pc}} = \frac{T}{\Sigma x_i T_{ci}} \quad (2.14)$$

$$P_{pr} = \frac{P}{P_{pc}} = \frac{P}{\Sigma x_i P_{ci}} \quad (2.15)$$

where x_i = mole fraction of $_i$th component.

The pseudo-critical conditions, which were proposed by W. B. Kay in 1936, are defined as the molar average of the critical properties of the mixture components. This concept was described in a previous article.[1] Reference to this earlier discussion for more details about the pseudo-critical is recommended.

The *density* of a gas mixture may be calculated from

the following equation, using a compressibility factor found from Figure 2.1 by the pseudo-reduced conditions.

$$\rho_m = \frac{PM_m}{z_m RT} \qquad (2.16)$$

where ρ_m = density, lb/cu ft
P = pressure, psia
M_m = average molecular weight of mixture
z_m = compressibility factor for mixture
R = 10.73 (psia) (cu ft/lb mole)/(°F)
T = temperature, °R

The compressibility factor is evaluated in the same way as for pure components, except the pseudo-reduced temperature and pressure of the mixture are used. For gas mixtures containing hydrogen and/or nitrogen, adjusted values of T_c and P_c should be used for the H_2 and N_2 in computing the pseudo-critical constants. Adding 8 C. to the critical temperatures and 8 atmospheres to the critical pressures of these two gases had been recommended previously for the application of the generalized compressibility factor chart to these two gases. A similar correction is suggested in computing the pseudo-criticals for mixtures containing these two gases.

Partial Volumes. For imperfect gases and nonideal solutions, particularly those involving highly polar compounds, deviations from the above simple additivity laws can be quite serious; and direct density measurement or partial molal volume data should be obtained.

The partial molal volume for a component is defined as:

$$\overline{V}_i = \left(\frac{\partial V}{\partial N_i}\right)_{p,\,t,\,n_j} \qquad (2.17)$$

where $\overline{V}_i$ = partial volume of component, i.e., cu ft/lb mole
V = volume of mixture, cu ft/lb moles
N_i = moles of component i, lb moles

Thus, the partial molal volume is a function of the temperature, pressure, and concentration.

The volume of the mixture in terms of the partial volume is then:

$$V = \Sigma N_i \overline{V}_i \qquad (2.18)$$

or for one mole of mixture

$$V = \Sigma x_i \overline{V}_i \qquad (2.19)$$

Partial volumes are more trouble than the equivalent component method and need not be used except where the simpler method gives questionable results. Partial molal volumes for mixture components may be evaluated by applying Equation 2.17 with an equation of state that represents the P-V-T-C data for the mixture. This calculation will be covered in a later chapter.

Equations of State. At this point it is of interest to review some of the equations of state that are used in correlating P-V-T data and calculating thermodynamic properties.

Three equations of state use two constants. These are the van der Waals, the Berthelot, and the Redlich-Kwong equations.

van der Waals Equation. Because of the shape of P versus V isotherm curves illustrated on Figure 2.2, the best fit to experimental data is obtained by the explicit-in-pressure form of equation. The van der Waals equation of state is the simplest and best known of this type and is:

$$P = \frac{RT}{V-b} - \frac{a}{V^2} \qquad (2.20)$$

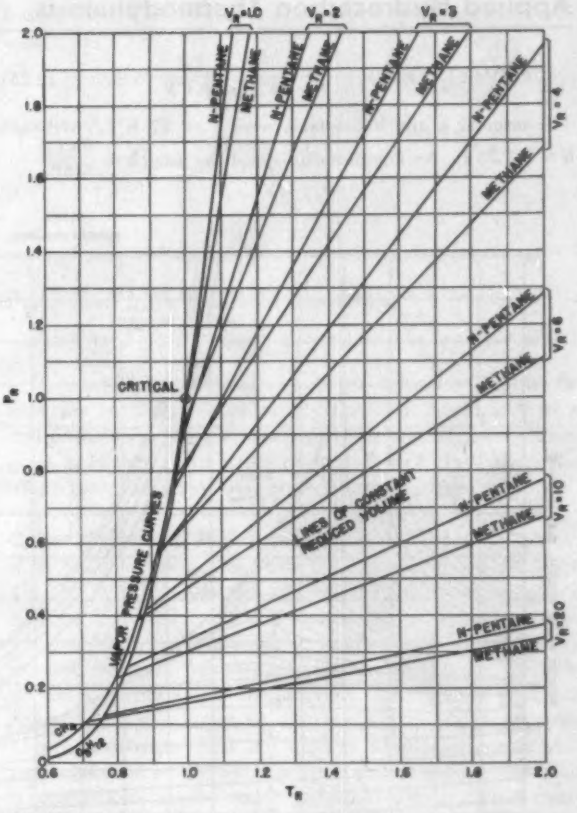


FIGURE 2.4—Reduced Isochor chart for methane and n-pentane.

Other forms of van der Waals equation are:

$$\left(P + \frac{a}{V^2}\right)(V-b) = RT \qquad (2.21)$$

$$PV/RT = z = 1 + \frac{b}{V-b} - \frac{a}{RTV} \qquad (2.22)$$

where

$$a = \frac{27}{64}\frac{R^2T_c^2}{P_c} \text{ and } b = \frac{RT_c}{8P_c}$$

For mixtures: $\sqrt{a} = \Sigma x_i \sqrt{a_i}$ and $b = \Sigma x_i b_i$.

In generalized units:

$$(P_r + 3/V_r^2)(3V_r - 1) = 8T_r \qquad (2.23)$$

A more convenient generalized form is obtained in terms of the ideal reduced volume, $V_{r'} = V/\frac{RT_c}{P_c}$, thus:

$$\left(P_r + \frac{27/64}{(V_r')^2}\right)\left(V_r' - \frac{1}{8}\right) = T_r \qquad (2.24)$$

In Equations 2.23 and 2.24, the constants are fixed, while in Equations 2.20, 2.21, and 2.22, the constants have different numerical values for each component. The van der Waals equation of state is of limited accuracy because the two constants do not permit fitting P-V-T data very accurately so more complex equations are required for precise work.

Berthelot Equation. The Berthelot equation of state is also a two constant equation of state similar to the van der Waals, the only difference being in the last term, which is a/TV^2 instead of a/V^2, as in Equation 2.20.

Following is the Berthelot counterpart of Equation 2.22

$$PV/RT = z = 1 + \frac{b}{V-b} - \frac{a}{RT^2V} \qquad (2.25)$$

The original a and b constants were $a = 27\ R^2T_c^2/64P_c$ and $b = RT_c/8\ P_c$. An improvement is made by using $b = \frac{9RT_c}{128P_c}$

Combining these values of a and b with Equation 25 and making two simplifying assumptions that are acceptable at higher volumes gives the following convenient equation:

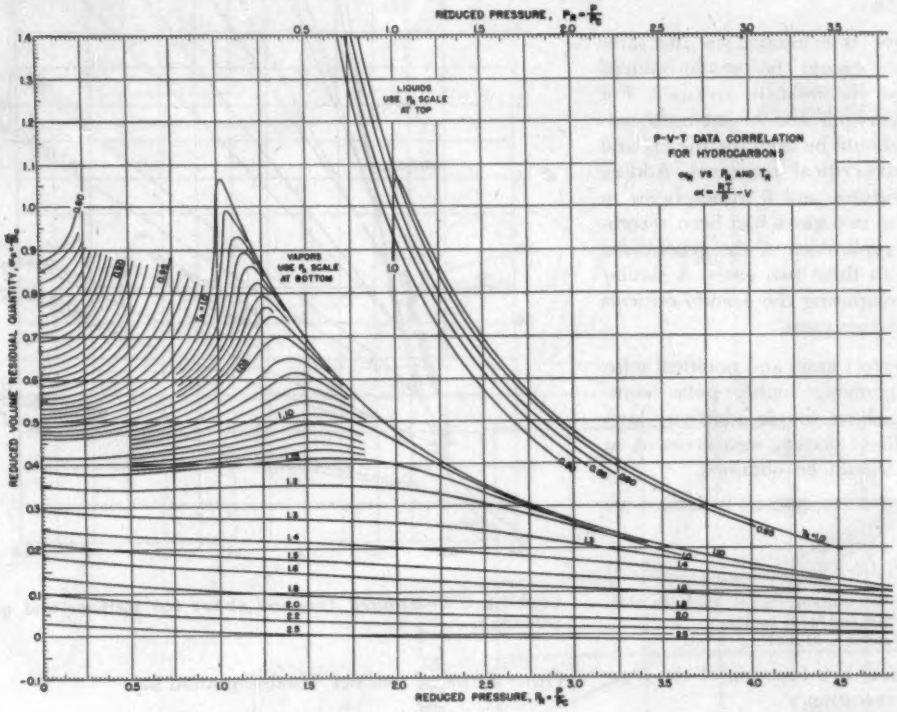
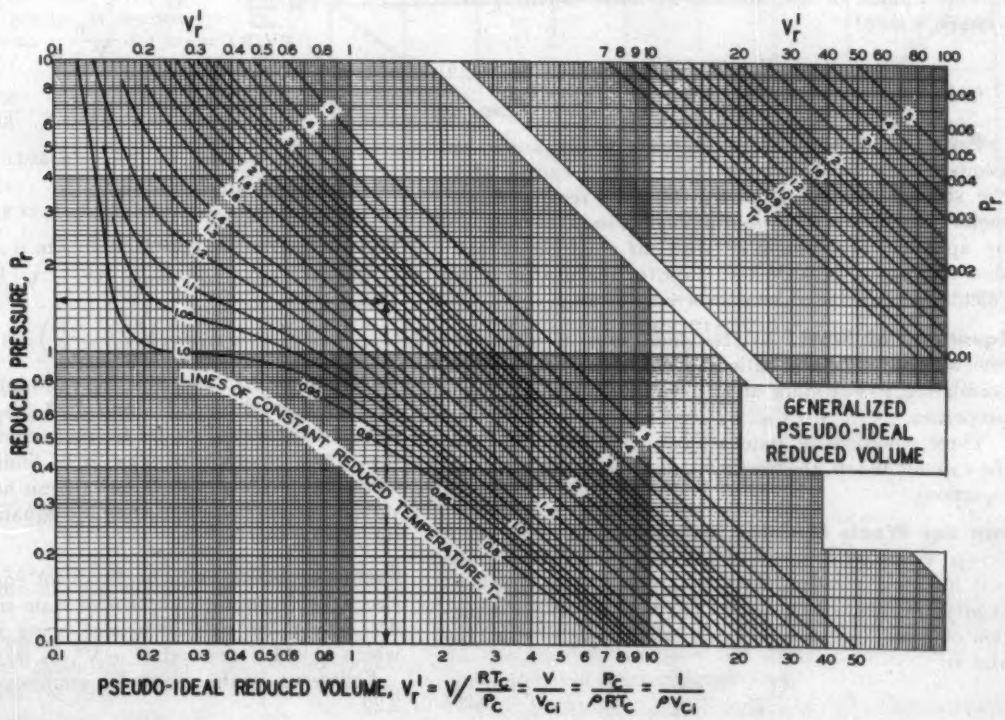

REDUCED PRESSURE, $P_R = \frac{P}{P_C}$
LIQUIDS USE P_R SCALE AT TOP
P-V-T DATA CORRELATION FOR HYDROCARBONS
α_R VS P_R AND T_R
$\alpha = \frac{RT}{P} - V$
VAPORS USE P_R SCALE AT BOTTOM
REDUCED VOLUME RESIDUAL QUANTITY, $\alpha_R = \frac{\alpha P_C}{RT_C}$
REDUCED PRESSURE, $P_R = \frac{P}{P_C}$

FIGURE 2.5 (At left)—Reduced volume residual correlation for hydrocarbons.

FIGURE 2.6 (Below)—Generalized pseudo-ideal reduced volume chart.


V_r'
REDUCED PRESSURE, P_r
LINES OF CONSTANT REDUCED TEMPERATURE, T_r
GENERALIZED PSEUDO-IDEAL REDUCED VOLUME
ρ_r
PSEUDO-IDEAL REDUCED VOLUME, $V_r' = V/\frac{RT_C}{P_C} = \frac{V}{V_{Ci}} = \frac{P_C}{\rho RT_C} = \frac{1}{\rho V_{Ci}}$

$$z = 1 + \frac{9P_r}{128T_r}\left(1 - \frac{6}{T_r^2}\right) \qquad (2.26)$$

These assumptions necessary in deriving Equation 2.26 are that

$$\frac{9}{128}\frac{RT_c}{P_c} <<< V$$

and

$$\frac{RT_c}{P_cV} \cong \frac{P_r}{T_r}$$

Equation 2.26 is a convenient approximation equation for the compressibility factor. Being explicit in z makes it much easier to use than the form of Equation 2.25 but not as accurate.

Redlich-Kwong Equation. This is another similar two-constant equation of state that is of interest. It is similar in form to the privious two equations of state. An important similarity is that the constants for both equations are computed from the critical temperature and pressure values. The following Redlich-Kwong[3] equation is more accurate, however.

$$P = \frac{RT}{(V-b)} - \frac{a}{T^{0.5}V(V+b)} \qquad (2.27)$$

The two constants a and b are related to the critical temperature and pressure, i.e.

$$a = \frac{0.4278\,R^2T_c^{2.5}}{P_c}$$

$$b = \frac{0.0867\,RT_c}{P_c}$$

For mixtures

$$\sqrt{a} = \Sigma\, x_i \sqrt{a_i}$$

or

$$b = \Sigma\, x_i b_i$$

The generalized form of Equation 2.27 is

$$P_r = \frac{T_r}{V_r' - 0.0867} - \frac{0.4278}{T_r^{0.5}V_r'(V_r' + 0.0867)} \qquad (2.28)$$

where: $V_r' = \dfrac{V}{RT_c/P_c}$ = ideal reduced volume

Redlich and Kwong[3] put the equation in another form, which they recommended for application, i.e.,

$$\frac{PV}{PT} = z = \frac{1}{1-h} - \left(\frac{A^2}{B}\right)\frac{h}{1+h} \qquad (2.29)$$

$$A^2 = \frac{a}{R^2T^{2.5}} = \frac{0.4278}{P_cT_r^{2.5}} \qquad (2.30)$$

$$B = \frac{b}{RT} = \frac{0.0867}{P_cT_r} \qquad (2.31)$$

$$h = \frac{BP}{Z} = \frac{b}{V} \qquad (2.32)$$

For mixtures

$$A = \Sigma\, x_iA_i$$
$$B = \Sigma\, x_iB_i$$

The numerical solution of the Redlich-Kwong equation involves the simultaneous solving of Equations 2.29 through 2.32. These equations have been applied to vapor phase fugacity coefficients.[4]

Wohl Equation. This equation of state has three constants which are also obtained from the critical constants. Its application to hydrocarbons has been discussed.[2] Following is the form that is comparable to Equations 2.20 and 2.27:

$$P = \frac{RT}{V-b} - \frac{a}{TV(V-b)} + \frac{c}{T^2V^2} \qquad (2.33)$$

where

$$a = 6\,P_cT_cV_c^2$$
$$b = V_c/4$$
$$c = 4\,P_cT_c^2V_c^2$$
$$\frac{RT_c}{P_cV_c} = \frac{15}{4}$$

In reduced form the Wohl equation is

$$P_r = \frac{15\,T_r}{4V_r - 1} - \frac{24}{T_rV_r(4V_r - 1)} + \frac{4}{T_r^2V_r^2} \qquad (2.34)$$

It would appear that the Wohl equation should be superior to the two-constant equations. According to a comparison made by Redlich and Kwong,[4] their equation gives a better fit to experimental P-V-T data than the other two and three constant equations of state.

Other Graphical P-V-T Correlations. Figure 2.4 shows a reduced isochor plot. On this plot reduced pressure ($P_r = P/P_c$) is plotted against reduced temperature ($T_r = T/T_c$) for lines of constant reduced volume ($V_r = V/V_c$). Although the isochors are straight, they do not coincide for the various hydrocarbons. Because of the straightness of the isochors, this type of plot has been used for computing the isothermal effect of pressure on enthalpy. It is not used in estimating vapor volumes because of the way the lines spread for the different hydrocarbons at the same reduced volume. This chart is included for illustration purposes only. It is not proposed for use in applying thermodynamics to the computation of hydrocarbons.

Figure 2.5 is a reduced volume residual correlation for hydrocarbons. The volume residual, proposed and used by Lewis and Randall, is the difference between the ideal gas volume RT/P and the actual gas volume V:

$$\alpha = \left(\frac{RT}{P} - V\right) \text{or } PV = (RT - P\alpha) \qquad (2.35)$$

This volume residual does not approach zero as P approaches zero but is the difference between the limits of the two terms RT/P and V, each of which approaches infinity:

$$\lim_{\substack{P \to O \\ \text{(finite)}}} \alpha = \lim_{\substack{P \to O \\ \text{(infinite)}}} \frac{RT}{P} - \lim_{\substack{P \to O \\ \text{(infinite)}}} V$$

The $P\alpha$ product does approach zero as P approaches zero, however.

The reduced volume residual, α_r, (where $\alpha_r = \alpha/\alpha_c$) has been plotted as a function of P_r and T_r and is shown in Figure 2.5. This correlation was prepared from pure hydrocarbon P-V-T data. From the critical properties, it is possible to determine the volume or density of a hydrocarbon at a given temperature and pressure. However, for vapors a compressibility factor chart is more convenient, but Figure 2.5 is helpful in determining volumes of subcooled liquids. This correlation was used as the basis for thermodynamic deviations to obtain the isothermal effects of pressure on the enthalpy, entropy, and heat capacity of hydrocarbons.

For deriving the generalized isothermal effect of pres-

TABLE 2.1—Psuedoideal Critical Volume, V_{ci}, Values for Various Hydrocarbons

COMPOUND	V_{ci}, ft.³/lb. Mole	COMPOUND	V_{ci}, ft.³/lb. Mole
Methane	5.47	cis-2-Butene	13.77
Ethane	8.34	trans-2-Butene	13.77
Propane	11.57	2-Methylpropene (isobutene)	13.91
n-Butane	14.91	1-Pentene	15.63
2-Methylpropane (isobutane)	14.89	2-Methyl-1-butene	17.72
n-Pentane	18.54	1-Hexene	20.92
2-Methylbutane (isopentane)	18.44	1-Heptene	24.57
2,2-Dimethylpropane (neopentane)	18.05	Propadiene (allene)	9.58
n-Hexane	22.40	1,2-Butadiene	13.12
2-Methylpentane	21.86	1,3-Butadiene	13.08
3-Methylpentane	21.50	Ethyne (acetylene)	6.60
2,2-Dimethylbutane (neohexane)	20.98	Propyne (methylacetylene)	10.17
2,3-Dimethylbutane	21.21	1-Butyne (ethylacetylene)	13.43
n-Heptane	26.29	2-Butyne (dimethylacetylene)	12.79
2-Methylhexane	25.63	Cyclopentane	15.09
3-Ethylpentane	24.86	Methylcyclopentane	18.74
2,2-Dimethylpentane	24.72	Ethylcyclopentane	22.32
2,4-Dimethylpentane	24.93	n-Propylcyclopentane	26.78
3,3-Dimethylpentane	23.51	Isopropylcyclopentane	26.69
2,2,3-Trimethylbutane (triptane)	23.47	Cyclohexane	19.06
n-Octane	30.37	Methylcyclohexane	21.91
2-Methylheptane	29.75	Ethylcyclohexane	26.47
3-Methylheptane	29.00	n-Propylcyclohexane	30.33
4-Methylheptane	28.89	n-Butylcyclohexane	28.19
2,4-Dimethylhexane	28.27	Cycloheptane	22.05
2,5-Dimethylhexane (diisobutyl)	29.04	Ethylcycloheptane	29.65
2,2,4-Trimethylpentane ("isooctane")	28.07	Benzene	15.22
n-Nonane	33.36	Toluene	18.77
2-Methyloctane	33.27	Ethylbenzene	21.35
2,2-Dimethylheptane	32.39	1,2-Dimethylbenzene (o-xylene)	22.53
3,3-Diethylpentane	31.76	1,3-Dimethylbenzene (m-xylene)	22.73
n-Decane	37.38	1,4-Dimethylbenzene (p-xylene)	23.22
Ethene (ethylene)	7.37	n-Propylbenzene	25.92
Propane	10.57	Isopropylbenzene (cumene)	25.96
1-Butene	13.90	Styrene (Phenyl Ethylene)	21.56

sure on thermodynamic properties from Figure 2.5, the following equation is written:

$$\frac{V}{\alpha_e} = \left(\frac{RT_c}{P_c \alpha_c}\right)\frac{T_r}{P_r} - \alpha_r \qquad (2.36)$$

values of α_c are given for each hydrocarbon. The group $(RT_c/P_c\,\alpha_c)$ is dimensionless and nearly constant at 1.38 (varies from 1.35 to 1.41) for hydrocarbons.[5]

Pseudoideal Reduced Volume Correlation. The compressibility factor correlations are satisfactory for estimating densities or volumes, but are very awkward when T or P are the unknowns. For these cases it is more convenient to use the pseudoideal reduced volume plot, Figure 2.6, which is derived from the compressibility factor correlations by the following relationship:

(P)	(V)	T	R
(atmospheres)	(cc/gm mole)	°K	82.0567
(lb/sq in abs)	(cu ft/lb mole)	°R	10.729
(lb/sq ft abs)	(cu ft/lb mole)	°R	1,545.04
(mm Hg)	(cc/gm mole)	°K	62,363.
Btu/lb mole		°R	1.98719
g-cal/gm mole		°K	1.98719

$$V_r' = \frac{V}{V_{ci}} = \frac{V}{RT_c/P_c} = \frac{zRT/P}{RT_c/P_c} \quad z = \frac{T_r}{P_r} \qquad (2.37)$$

$$\text{where } V_{ci} = \frac{RT_c}{P_c} = z_c V_c = V_c + \alpha_c \qquad (2.38)$$

Values of V_r' are plotted against P_r for lines of constant T_r on log-log coordinates. Values of V_{ci} may be obtained from Table 2.1 for many pure components. For components not listed, the value of V_{ci} may be found from T_c and P_c using the above relationship.

For mixtures, the values of V_{ci} should be found from the pseudo-critical temperature and pressure, i.e.,

$$V_{ci} = \frac{10.73 T_{pc}}{P_{pc}}$$

where V_{ci} = pseudoideal critical volume, cu ft/lb mole
T_{pc} = pseudocritical temperature, °F
P_{pc} = pseudocritical pressure, psia

Units for Calculations. Vapor densities required in process engineering calculations may be estimated from

$$z = PV/RT = \text{generalized function of } T_r \text{ and } P_r$$

Consistent units must be used for P, V, R, and T to make z dimensionless. In other words, the gas constant R is expressed in energy units divided by temperature. The following tabulation lists the value of R for a few of the many P-V-T units:

Compressibility factors are given on Figure 2.1. This was prepared from pure component P-V-T data but can be used for mixtures by a procedure outlined before.

With values of the compressibility factor, z, the density of a vapor may be found from Equation 2.16:

For convenience the definitions of the various reduced parameters are repeated:

$$T_r = T/T_c; P_r = P/P_c; V_r = V/V_c; \rho_r = 1/V_r \text{ or } d_r = \frac{1}{V_r};$$

$$V_{cr} = V/V_{ci};\ d_r = d/d_c;\ V_{ci} = RT_c/P_c;$$

$$d = \frac{RT}{P} - V;\ d_c = \frac{RT_c}{P_c} - V_c$$

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Next, Part 3: Liquid and Vapor Densities

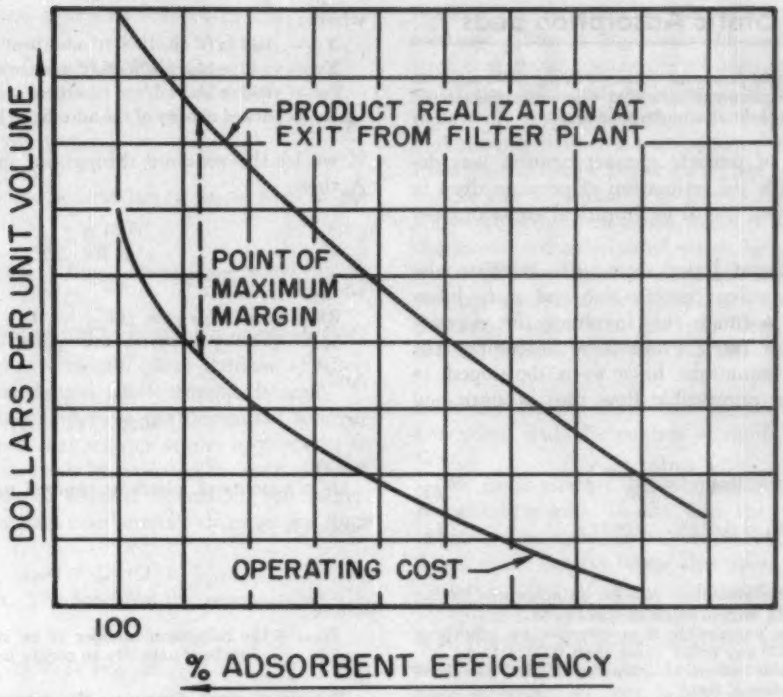

FIGURE 1—To find the most favorable operating point, data are requuired on operating cost and product value.

How to Design Static Adsorption Beds

Here is a discussion and the equations for the factors involved in the design of static adsorption beds.

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STATIC ADSORPTION beds may be used for the decolorization, purification, and finishing of light distillate, lubricating oils, and waxes. They usually are operated in a cyclic process wherein the oil to be refined is passed through one stationary bed of granular adsorbent under controlled conditions. Feed is continued until the filtrate has reached the desired specification. The bed is then drained of oil held in the voids, washed with solvent, steamed and the adsorbent regenerated for reuse. Here are some useful equations to use in the design of these beds.

The equations and data herein were developed on the attapulsite type of clay and activated bauxites. Although it is not certainly established that this material accurately applies to other types of adsorbents, the methods should make studies easier for other type of adsorbents.

DESIGN EQUATIONS

A number of mathematical treatments of the properties of packed beds have been published. Those most practicable for use with the adsorbents in question are those of Allen[1] and Leva, et al.[4] Both these workers characterize particle size in terms of an equivalent spherical diameter. Although computed by different equations, their numerical values are almost identical. The simpler equations of Leva are given below:

$$dp = \sqrt{d_1 \times d_2} \qquad (1)$$

$$Dp = \frac{adp_1 + bdp_2 + cdp_3 + \cdots ndp_n}{12} \qquad (2)$$

where:

dp = mean particle diameter for any screen fraction where d_1 and d_2 are the values in inches of the rated openings of the adjacent sieve sizes defining the fraction.

a,b,c, . . . n = the weight fractions obtained in the sieve analysis.
Dp = mean equivalent spherical diameter characterizing the total adsorbent in feet.

While this concept of particle characterization was developed principally for the estimation of pressure drop in flow, it has also proved useful in empirical equations defining flow rate.

Fitzsimons, Capell and Jones[2] seem to be the first who published data concerning particle size and rate. Johnston[3] later proposed a rough rule involving the viscosity of the fluid and flow rates. From these beginnings the following empirical equations have been developed to define the maximum permissible flow rate in static-bed liquid phase adsorbers:

$$Rx = Ro\left(\frac{0.0101\text{-}Dp}{0.008}\right) \quad (3)$$

$$\log Ro = 0.0385 - 0.0387\,\mu \quad (4)$$

where:
Ro = maximum permissible flow rate for an adsorbent having Dp = 0.0021 foot in units of vol/vol/hr.
Rx = the maximum permissible flow rate for an adsorbent where Dp = any other value than 0.0021 foot.
Dp = mean equivalent spherical diameter of the adsorbent being considered, feet.
μ = viscosity of the fluid at flowing temperature, centipoises.

Although equations (3) and (4) are empirical and result from the analysis of data collected over many years, they appear to represent the limiting rate for petroleum adsorption within ±5 percent. Actually, it is probable that the relation with viscosity actually includes the effects of adhesion and interfacial tension since both these properties have roughly the same temperature coefficient of change as that of viscosity. A recent survey has shown that the majority of the percolation rates now in use in petroleum refineries fall in the range of 50-90 percent of those computed by equations (3) and (4). Accordingly, 90 percent of the computed rate is taken as a safe design figure. The equations, of course, assume isothermal flow conditions.

Filter Shells (Percolators). The percolator is essentially a vertical cylindrical vessel equipped with means of retaining the absorbent bed in place. Figure 1 shows several conventional shell and support designs. As previously mentioned, shells having a diameter of less than 5 feet should have a minimum bed height of 15 feet. Shells greater than 5 feet in diameter should have a ratio of height to diameter of 3-4. The height dimension in practice is increased to allow for dished head attachment, side nozzles, etc.

In sizing the percolator shells it must be remembered that this is a cyclic process but the filter plant must run an average throughput over a long period of time. Thus, the first step is to adjust yield data to the average or equilibrium adsorbent efficiency expected. It is most convenient to have yield data on a volume basis for easy computation. Yields in barrels per ton can be converted to volume units by the following relation:

$$Yv = Yw\,D_b/2 \quad (5)$$

$$Yc = 5.61\,Yw\,D_b/2 \quad (6)$$

where:
Yc = yield in ft³ oil/1000 ft³ adsorbent
Yv = yield in bbls oil/1000 ft³ adsorbent
Yw = yield in bbls oil/ton adsorbent
D_b = packed density of the adsorbent, lbs/ft³

If we let the required throughput in barrels be equal to A, then:

$$\frac{5.61\,A}{24\,Rx} = Q_r \quad (7)$$

where:
Rx = permissible rate (Equation 4)
Q_r = quantity of adsorbent required to maintain rate, ft³

And,

$$5610\,A/Yc = Qy \quad (8)$$

where:
Qy = quantity of adsorbent required to give yield, ft³

Since $Qy > Qr$:

$$Qy/Q_r = N_{min} \quad (9)$$

where:
N_{min} = the minimum number of on stream filters of Q_r adsorbent capacity to satisfy both rate and yield.

We must next compute the pressure drop to be expected. For this we use Allen's[1] equations. Since all percolation flow should be in the laminar region, the reference should be consulted if turbulent or transition flow is encountered.

$$Re = Dp\,G/\mu \quad (10)$$

$$f = 480/Re \text{ when } Re < 10 \quad (11)$$

$$\frac{\Delta P}{L} = \frac{2\,f\,G^2}{144\,Dp\,g\,\rho} \quad (12)$$

where:
Re = modified Reynolds number, dimensionless
Dp = see Equation (2), feet
G = mass velocity of the fluid calculated on the cross-section of the empty vessel, lbs/sec/ft²
ΔP = pressure drop, lbs/in²
L = adsorbent bed depth, feet
f = modified friction factor, dimensionless
g = Newtonian constant, 32.2, lb(ft)/lb(sec²)
μ = viscosity of the fluid at flowing temperature, lbs/ft/sec = centipoises × 0.000672
ρ = fluid density at flowing temperature, lbs/ft³

These equations only give the pressure drop across the adsorbent bed itself. Pressure drop through piping is estimated by conventional means. Pressure drop across the usual supports may be approximated by using 1.5-2.5 $\Delta P/L$. However, it is better to make a rigorous calculation using the correct hydraulic diameter. For conical sections of 45°, pressure drop is approximately 0.45 ΔP for the cylindrical section when the height to diameter ratio is 3. It is more accurate to calculate $\Delta P/L$ for a number of cross-sectional areas of the cone and integrate these values between the larger and smaller diameters.

The next step requires an estimate of the cycle time involved. This may be estimated as follows:

1. Charge with adsorbent—use 3-4 hours and check later.

2. Fill with oil—max. rate 0.25 vol/vol/hr
3. Soak—1 hour
4. Run to product—$Y_c \times Q_r/R_x$ = hours
5. Drain—6-8 hours
6. Wash—use 24 hours
7. Steam—$Q_r D_b/250$ = hours
8. Dump—use 4 hours

The sum of these to the nearest larger whole hour is the cycle time, θ.

Then:

$$5610\ A/Q_r\ Y_c = F, \text{ the filter turnovers per 24 hrs.} \quad (13)$$

And:

$$\theta F/24 = N_s, \text{ the actual number of filter shells required.} \quad (14)$$

Equation (14) often gives a fractional number of filters in which case the next largest whole number is used.

The procedure above refers to the design for a single product. This is a case that seldom occurs in practice, so the same computations must be repeated for each product involved. In the case of blocked operation, the largest number of filters for any one product dictates the filter plant size.

Regenerating Kiln. The load for the regenerating kiln is:

$$Q_r F/24 = \text{ft}^3/\text{hr} \quad (15)$$

or:

$$\frac{Q_r D_b F}{24 \times 2000} = \text{tons/hr} \quad (16)$$

Since the shortest possible time for clean burning is required, the rated kiln capacity should never exceed the expected load. The kiln manufacturers usually rate their kilns at contact times longer than desirable for maximum regenerated efficiency. The kiln should be equipped with an after cooler which will allow control of the adsorbent temperature so that it may reach the filter at the preconceived operating temperature.

Handling Equipment. The recommended adsorbent handling equipment consists of dished belt conveyors, chain bucket elevators, belt loading and unloading devices and appropriate storage bins. To maintain a four hour period for filter charging, the handling capacity of conveyors and elevators must be $Q_r/4$ which is considerably faster than the kiln regeneration rate. Consequently, an insulated bin having a capacity of Q_r should be provided for regenerated adsorbent. A kiln feed bin of similar size for spent adsorbent is also needed.

If adsorbent is purchased in bulk, a storage bin and unloading conveyor are required for adsorbent receipts. Otherwise, housing for bag storage is required.

Oil Handling Equipment. Pumps and piping are required for raw oil, solvent naphtha, product and wash solution. Piping is required for compressed air and steam.

The capacity and pressure head required for the pumps is, of course, dictated by the quantities computed for the filter shells. Reciprocating steam pumps may be used if there is a requirement for exhaust steam. Otherwise, rotary or centrifugal pumps are more desirable because of less pulsating flow. The usual provisions for standby pumps should be made.

Piping should be of adequate size to handle maximum flow with minimum pressure drop. The chief problem is manifolding to minimize the chances of contaminating viscosity oil with naphtha. The arrangement is usually such that steam can purge all lines used in common such as at the inlet and outlet of a filter. Double valving is commonly used in manifolds as well as removable blinds.

Although it is common practice to blend the streams from several filters, better yields are obtained if each filter can be run individually to specification product. Thus, it is desirable that run down tanks of size adequate to take the maximum anticipated yields be provided, at least for the maximum number of on stream filters. Storage and run tanks for feed, product, clean naphtha, recycle wash, degraded wash, etc., are provided in accordance with general refinery inventory practice.

Control. In the static-bed percolation process we are concerned with the control of temperature, pressure and flow.

We must control the temperatures in and out of the regenerating kiln. In the kiln the main necessity is to avoid temperatures in the *adsorbent bed* above 1100 F. Thus, exact control below this point is unnecessary and a variation of ± 10 F. unimportant. Usually the kiln is equipped with thermocouples and a multipoint temperature recorder. Kiln temperatures are hand controlled to this indication. Since it is seldom practical to place thermocouples so that actual bed temperatures are recorded, the relation between indicated and actual temperatures must be carefully determined.

The regenerated adsorbent should be brought to the filter as nearly as possible at the temperature at which filtration is to occur. Since conveyor belts will seldom withstand an excess of 300 F., a tubular water cooled cooler permits adjustment between the kiln, handling system, and filter.

Inasmuch as we desire to filter under as nearly isothermal conditions as possible, the feed as well as the adsorbent must be brought to filtering temperature. Hand control and a temperature indication are normally adequate.

Flow is controlled at the filter outlet. Usually the best means of controlling is a replaceable orifice. Assuming that the flow is isothermal, this also requires a controlled pressure. Usually the filters are fed by a constant pressure loop system. A back-pressure relief valve returns excess feed to the pump suction. Alternately, flow may be controlled by a flow controller or by hand throttling. In the latter a rotometer is often used for flow indication. Temperature, pressure and flow are similarly controlled during washing.

Utilities. Steam for purging should be dry. If exhaust steam is used, a moderate superheat is desirable. Heating steam is also required.

Air is often used to assist drainage. Ordinary 25 pounds compressed air is satisfactory.

If a tubular cooler is used, cooling water will be required.

Fuel for the kiln may be either distillate fuel oil or gas.

Electric power is required for handling equipment, kiln drive and pump drives.

Buildings. The modern trend is to avoid housing the filter plant in elaborate buildings. Filters are wrapped

with steam coils and given a weather-proof insulation. The supporting steel work is roofed over and the working areas above and below the filters protected from the weather with galvanized iron or transite board. Exposed runs of conveyor are similarly housed.

The kiln is roofed over only. Housing for pumps, controls and office space are the only complete buildings.

Layout. With a considerable number of filters, the filters are ordinarily placed in a parallel row which may be served by a common conveyor system. Arrangement should be predicated on obtaining minimum piping and conveying runs. Safety requirements dictate that the kiln should be either protected by a fire wall or placed at a safe distance from naphtha vapor exposure. Close placement with an adequate fire wall usually affords savings in conveyors and elevators.

Wash Reduction. The naphtha used in filter washing must be recovered for re-use and the denuded oil either returned to the system or segregated for other uses. This is done by distillation. Although batch steam and fire stills are still in use for wash distillation, a modern tube still-column arrangement is best. Here maximum temperatures can be limited especially if the column is operated with steam and a barometric condenser. Operating costs are appreciably lower.

FILTER PLANT OPERATION

The two most important points in operating a filter plant are control of flow rates and regenerating temperatures. Exceeding permissible flow rates for the existing conditions lowers yields in approximately the same percentage that the rate is exceeded. Exceeding maximum regeneration temperatures shortens the efficient life of the adsorbent.

OPERATING COSTS

The items which go into the direct operating costs are:

1. Adsorbent—this cost is the delivered cost divided by the number of cycles of use before discard. With an equilibrium operation it is the delivered cost multiplied by the percent make-up; 2 percent make-up usually is used for estimating.
2. Naphtha Loss—usually estimated at 2 percent of the volume cycled. This is one of the larger cost items and can be controlled by plant design and operation.
3. Steam
   a. Purging
   b. Heating
   c. Pumps (if steam pumps are used)
4. Electric power
5. Fuel
6. Water (if tubular coolers are used)
7. Wash reduction—usually the plant has a distillation cost for this figure which runs $0.35-$0.50 per barrel. It may be broken down into fuel, water, electricity, maintenance and labor items, if desired.
8. Maintenance (labor and materials)
9. Operating labor

The sum of these items constitutes the direct operating cost. Normally, this cost runs $0.004 to $0.05 per gallon of product.

Operating costs and yields are both a function of the adsorbent efficiency. Since the filtering operation is most often the final refining step, it is easy to arrive at a realization for the volume of product at the point of exit from the filter plant. If this realization and the operating cost, both in the same units, are plotted versus adsorbent efficiency, curves like those in Figure 1 will result. The point of greatest margin between these curves is, of course, the best point at which to operate. If the discard system is used, the discard point is determined by the number of cycles which produce an *average* efficiency giving the point of greatest margin.

Curves such as Figure 1 do not necessarily show whether the operation is profitable or not unless the cost curve also contains items for the cost of feed stock and overhead and indirect charges. It is often difficult to assign an accurate cost to feed stock. However, whether profitable or not, added costs on a unit basis will simply displace the cost curve upward. Hence, the point of margin still is the criterion of the operation giving the most profit or the least loss.

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Laughlin

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Charts Make Cat Cracker Balance Easier

These handy charts will help you check unit data or examine factors of regenerator temperatures for catalytic crackers.

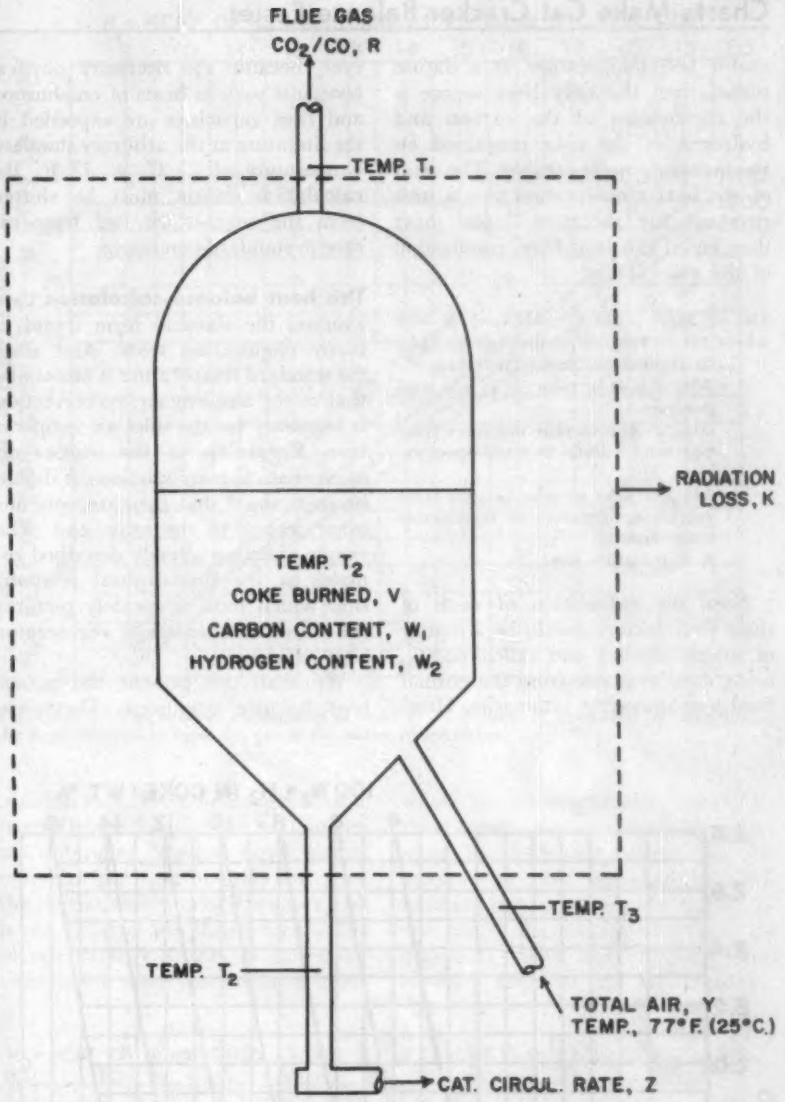

FIGURE 1—The best way to understand regenerator performance is to consider it a completely isolated system.

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THE IMPORTANT factors in regenerator heat balances can be seen in the charts developed here. They show cracking catalyst has a direct influence on the dependent variables of CO_2/CO ratio and quantity of coke burned. The catalyst indirectly influences the independent variables of air rate, regenerator bed temperature and catalyst circulation rate through the coke burning rate of the catalyst. The calculation can be used to detect erroneous data and to set up new operating conditions.

The regenerator of a fluid unit is not a separate and self-sufficient entity. It is physically and operationally tied to the reactor. But this does not mean that its performance must be studied as part of the entire complex. We believe that the best understanding of the whys and wherefores of regenerator performance results from considering it as a completely isolated system as shown in Figure 1.

The basic factors controlling regenerator heat balance are simple enough. If one assumes the regen-

erator bed temperature as a datum plane, then the only heat source is the combustion of the carbon and hydrogen of the coke contained on the incoming spent catalyst. The total of the heat requirements plus a unit constant for radiation losses must then equal this heat from combustion of the coke. Thus:

$\Delta H_c - \Delta H_a - \Delta H_{fg} - \Delta H_{cat} - K = 0$

where ΔH_c = heat of combustion for coke at regenerator bed temperature.

ΔH_a = heat to raise air to bed temperature.

ΔH_{fg} = heat to raise flue gases from bed temperature to stack temperature.

ΔH_{cat} = heat to raise catalyst from reactor temperature to regenerator temperature.

K = radiation loss.

Now the calculation of each of these four factors should be a matter of simple algebra and stoichiometry, using data available from the normal fluid unit operating summaries. However, because the necessary physical constants such as heats of combustion and heat capacities are expressed in the literature at the arbitrary standard temperature of 25 C. = 77 F., the calculation datum must be shifted from the regenerator bed temperature to standard conditions.

The heat balance calculation then assumes the classical form found in many engineering texts. And since the standard temperature is essentially that of the ambient air, no correction is necessary for the inlet air temperature. Regardless of the increased mathematical manipulations, it should be understood that they are only another means to the same end. The simple equation already described remains as the fundamental relationship which most accurately pictures the actual mechanism of regenerator heat balance.

We shall not present the actual heat balance equations. These are contained in the Appendix. Instead, we have reduced the equations to more practical and understandable graphs. Let us first consider the matter of heat release plotted in Figure 2.

The relative heats of combustion of hydrogen to water vs. carbon to carbon dioxide vs. carbon to carbon monoxide make it apparent that higher CO_2/CO ratios and higher hydrogen in coke both result in greater heat release. But above that, the hydrogen in the coke is considerably more influential on heat balance than is the CO_2/CO ratio except at very low CO_2/CO ratios. For example, an increase in hydrogen of 1 percent is equal in effect to about a 0.35 change in CO_2/CO ratio. As will be seen later, this increase in heat release will result in an increase in the regenerator bed temperature if catalyst circulation rate is not changed. Thus the importance of efficient stripping to maintain a low hydrogen content in the coke becomes obvious, especially in those units which are troubled by high regenerator bed temperature.

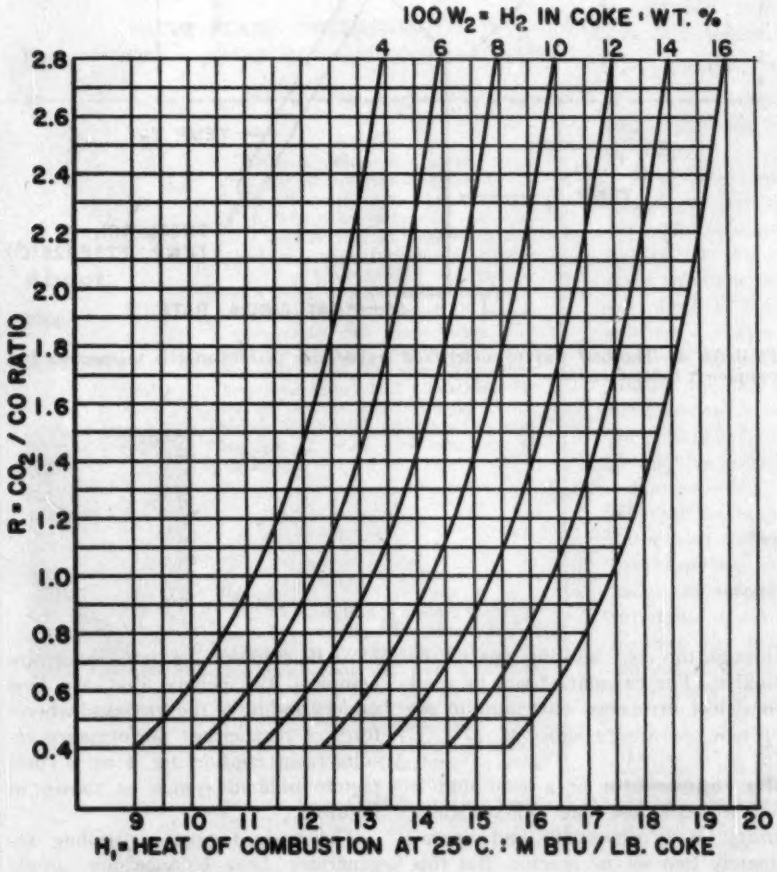

FIGURE 2—Many factors affect the heat of combustion of coke.

The heat of combustion calculated with Figure 2 is expressed in terms of M BTU per pound of coke, after all products of combustion have been cooled to 77 F. and the water vapor condensed. These combustion products must then be heated, mathematically, back to the regenerator outlet temperature, and the heat required to do this must be subtracted from the heat of combustion just determined. Figure 3 performs both functions.

Observe that the flue gas outlet temperature is not necessarily the same as that of the bed, the difference being due to the degree of afterburning, use of spray water or quenching steam, and the like. Observe, too, that by flue gas outlet temperature, we mean the temperature at the cyclone outlet, not at some distant point in the stack. But the chart makes clear that a change in flue gas outlet temperature of as much as several hundred degrees has only a small effect on heat balance. This is because of the relatively low enthalpy of the flue gases. So attempting to control regenerator bed temperature through manipulation of the flue gas outlet temperature is not recommended. However, this does not

mean that high flue gas temperatures are unimportant. The opposite is true, since a high flue gas temperature is a symptom of a thermal condition in the regenerator which might cause severe damage to catalyst and cyclones.

The result of calculations with Figures 2 and 3 is the heat available after deductions for the heat needed to raise the temperature of the theoretical air requirement to reaction temperature and for the heat lost to the stack, still in terms of M BTU per pound of coke. The graph in Figure 4 is a simple multiplication of this available heat by the actual pounds of coke burned per hour to convert from a unit of coke basis to an absolute basis per unit of time. In order to permit one graph to be used for fluid units of any capacity, we have expressed the "coke burned" parameter as "V" x 10^x where x is any digit which will bring the observed data within the range of the scales. This same digit must then be used consistently on subsequent graphs. It becomes a constant for each particular fluid unit.

While the preceding calculations are based on the theoretical weight of air required to burn the coke, all operating plants use excess air. Figure 5 rectifies this omission by deducting the heat required to raise this excess air from 77 F. to the flue gas outlet temperature. Don't be misled by the parameter "total air." Although the graph actually accounts for only the heat absorbed by the excess air, we have manipulated the data so that only the more conveniently available total air value is needed.

The final result of the calculations made using Figures 2 through 5 in consecutive order is the actual amount of heat available for raising the temperature of the circulating catalyst. But the heat requirement of the catalyst can be calculated independently, since both the reactor and regenerator bed temperatures are known. With the establishment of the heat capacity of the catalyst, the only error lies in the assumption that the small amount of coke contained on it has the same heat capacity as the catalyst. The effect of this assumption is very small.

Figure 6 relates the heat required to raise the catalyst temperature from reactor temperature to regenerator bed temperature as a function of the only other variable, the catalyst circulation rate. We now have available from Figures 5 and 6 two heat values, the difference between which should represent the heat actually lost from the regenerator system. However, this is not yet true for units which utilize recycle catalyst coolers, or for operations which use either steam or spray water in the regenerator dome. In these cases, separate calculations must be made to determine the amounts of heat absorbed by each mechanism, and the total added to the heat absorption calculated by Figure 6. After this correction is made, if required, the difference be-

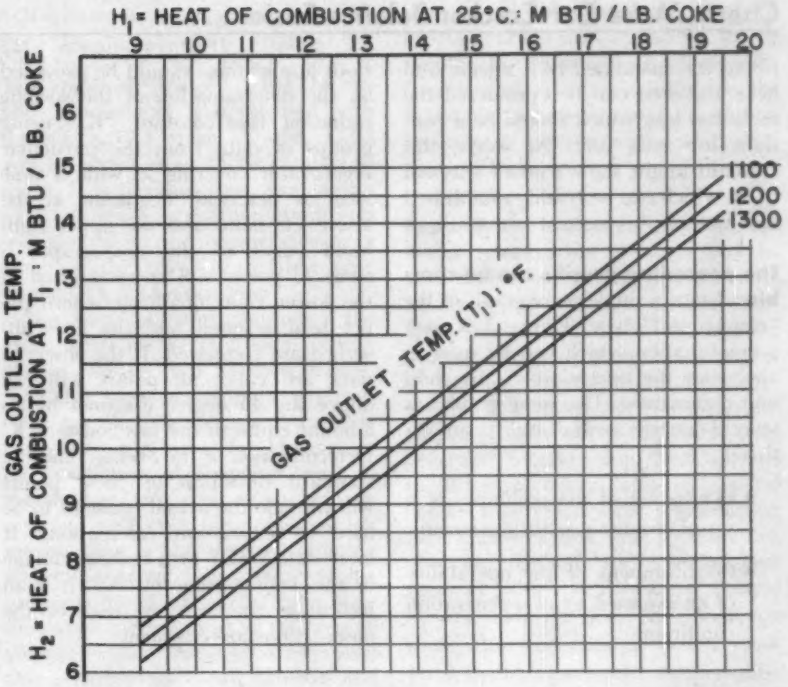
H1 = HEAT OF COMBUSTION AT 25°C. : M BTU / LB. COKE
9 10 11 12 13 14 15 16 17 18 19 20
H2 = HEAT OF COMBUSTION AT T1 : M BTU / LB. COKE
GAS OUTLET TEMP.
16 15 14 13 12 11 10 9 8 7 6
GAS OUTLET TEMP. (T1) : °F.
1100
1200
1300

FIGURE 3—The heat of combustion of coke at 77 F must be corrected by considering the heat required to raise the gas to the outlet temperature.

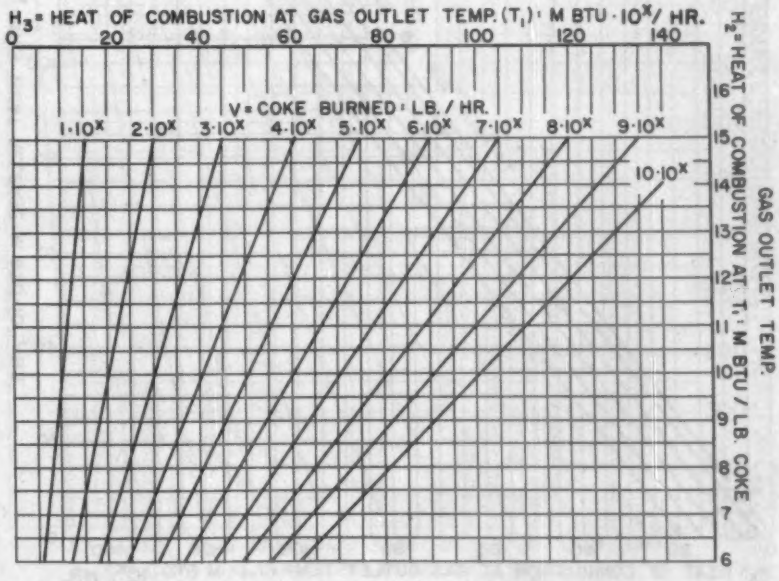
H3 = HEAT OF COMBUSTION AT GAS OUTLET TEMP. (T1) : M BTU · 10X / HR.
0 20 40 60 80 100 120 140
V = COKE BURNED : LB. / HR.
1·10X 2·10X 3·10X 4·10X 5·10X 6·10X 7·10X 8·10X 9·10X
10·10X
H2 = HEAT OF COMBUSTION AT T1 : M BTU / LB. COKE
GAS OUTLET TEMP.
16 15 14 13 12 11 10 9 8 7 6

FIGURE 4—To convert the charts to a unit of time, the amount of coke must be applied. The value of "x" used in coke burned parameter must be used in all subsequent charts.

tween the calculated heat release and heat absorbed can be considered the radiation loss, which should be a constant for each unit. At worst, this constant might show a small seasonal trend which can be readily established by experience.

The preceding graphs can be combined into a single nomograph of the "run-around" type. Figure 7 is such a combination which can be used in analyzing the operation of any fluid unit regenerator. This nomograph has several general areas of utility, among them:

- Evaluation of the reliability of a set of regenerator measurements.
- Establishment of the operability of an assumed set of regeneration conditions.

Both applications should be preceded by the determination of the specific radiation loss constant "K," using groups of data from the particular regenerator covering as wide a time span as practical. Beginning at the lower left hand and the upper right hand edges of the nomograph, a series of points will be established in the lower right quadrant where the net heat released and the heat absorbed are compared. If the observed data are valid, all points will fall above the 45 degree diagonal by an amount equal to the loss constant K. Determination of the average and the standard deviation of these points will provide the actual constant to be used in subsequent calculations. If later data result in a radical change in this known value of "K," it is an indication that one or more of the observations are erroneous.

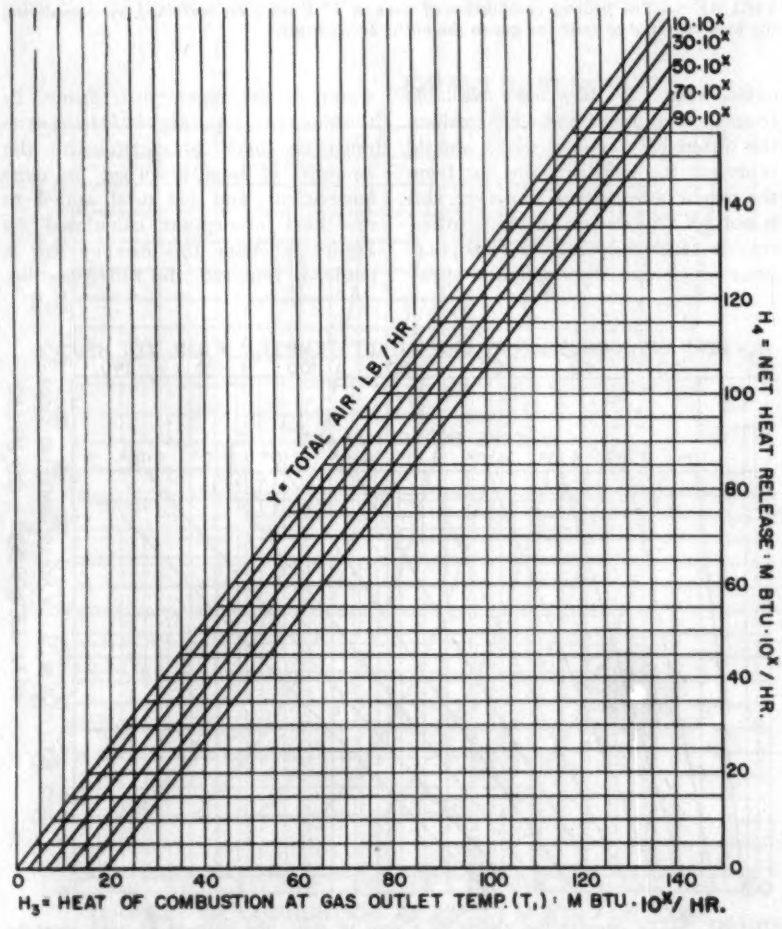

FIGURE 5—Most plants operate with an excess of air. This chart corrects for the excess even though it is recorded as total air used.

The likelihood of erroneous observations is not remote. We are all inclined to accept recorded measurements as being unquestionably accurate. But this is not necessarily the case in a large fluid unit. For example, a single fixed thermocouple may be used to measure and record the catalyst bed temperature. It is easy enough for an instrument specialist to guarantee the accuracy of the thermocouple and its measuring and recording instruments. But this is no assurance that the thermocouple itself is located in a position which represents the true average catalyst bed temperature. Experience has shown that wide temperature differences can exist in different portions of a large fluidized catalyst bed because of poor mechanical air distribution or because of poor fluidization resulting from a bad catalyst particle size distribution. So a rapid check with the nomograph will either verify the reliability of the data as a whole, or assist in locating the odd observation.

Let us look at an example. Table 1 contains monthly measurements on the regenerator of a large fluid unit. The monthly radiation loss constants have been determined using the nomograph. Visual inspection indicates the lack of seasonal change in the constant, possibly because the plant is located in a warm climate. Furthermore, statistical analysis of the 16 constants indicates that their variability around the average follows a normal probability distribution. Hence the average "K" of 14,000,000 Btu/hr. can be used as the radiation loss constant for this regenerator. Now suppose that the hydrogen content of the coke for July had been 9.3 per cent rather than the 7.3 per cent actually observed. Inspection of all the hydrogen data would not have caused any suspicion, since the hydrogen content of the coke during the previous December had also been 9.3 per cent. But the resultant "K" would have been 50,000,000 Btu/hr., far outside of the established 95 percent confidence limit of 30,000,000 Btu/hr. By means of the nomograph, the error is detectable.

The use of the nomograph to determine the operability of a new set of regenerator conditions is straightforward. Suppose that it is desired to operate the reactor of the previously mentioned unit at a higher conversion level which requires a reactor

bed temperature of 935 F. and a catalyst circulation rate of 37 tons per minute. The question of concern is whether the resultant 4500 pounds per hour increase in coke yield will raise the regenerator temperature beyond an imposed maximum of 1160 F. Since neither the catalyst nor the charge stock is to be changed, we can assume that the CO_2/CO ratio of the flue gas and the hydrogen content of the coke should remain essentially constant. The quantity of air required to burn the new amount of coke is calculated to be 323,000 pounds per hour, basis the operating experience tabulated in Table 1. With this information, and the radiation loss constant of 1.43×10^4 M Btu/hr. already established, a rapid calculation with the nomograph predicts that the differential temperature between regenerator and reactor will be 242 F. So with the reactor at 935 F., the resultant regenerator temperature would be 1177 F., hence the desired reactor conditions would result in an inoperable regenerator.

How the cracking catalyst affects the regeneration variables can be seen from these nomographs. To do this, we shall consider each variable in the order contained in the correlation.

The CO_2/CO ratio in the flue gas is known to depend upon the type of catalyst and its degree of contamination by metals in the charge stock. For example, we are aware of a certain Canadian crude which is high in soluble iron content so that the cracking catalyst is often highly contaminated. In one fluid unit, the CO_2/CO ratio reached the unusual level of 5 when the iron content of the catalyst was 4.2 weight percent. A subsequent improvement in feed preparation lowered the iron on catalyst to 1.0 weight percent, and the CO_2/CO ratio dropped to 2.9. At a constant hydrogen content in coke of 10 percent, this reduction in CO_2/CO ratio lowered the heat of combustion nearly 9 percent, sufficient to severely affect heat balance and regenerator temperature.

Different types of catalyst have inherent CO_2/CO characteristics. While actual numbers may vary from operation to operation, the following scale of values is relatively typical of commercial practice:

Bentonite base natural catalyst	2.0
Sulfur-resistant natural catalyst	1.5
13% alumina synthetic catalyst	1.2

The graph in Figure 2 shows the relative amounts of heat released with these CO_2/CO ratios as 1.08, 1.035 and 1.0 based on synthetic catalyst as unity. It is obvious, then, that somewhat different operating conditions will prevail in the regenerator as a result of the effect of catalyst type on the CO_2/CO ratio alone.

We have already mentioned the great effect of the hydrogen content of the coke on heat balance. Unfortunately, commercial data are not clear on the relationship of catalyst to hydrogen in coke, for changes in the mechanics of stripping tend to overshadow any real effects of the catalyst itself. We have data which suggest that a 13 percent alumina synthetic catalyst of high pore volume produces less hydrogen in coke than the same catalyst with a lower pore volume, possibly because of improved ease of stripping. Conn, Meehan and Shankland reported[1] silica-magnesia catalyst was more difficult to strip than silica-alumina, and that its average pore size appeared to be smaller. Both these observations indicate the catalyst may influence the hydrogen in coke through a relation between its pore structure and stripping efficiency.

Experience indicates the flue gas outlet temperature is controlled by unit design, operating practice and, at times, by catalyst performance. Unit design and operating practice dictate the amount of spray water or dispersion steam which are necessary to eliminate afterburning, and these naturally affect the outlet temperature. Afterburning itself appears to originate from any of several causes: high regenerator temperature, high excess oxygen, and poor air distribution through the catalyst bed, none of which is necessarily caused by the catalyst. But this does not mean that the catalyst is never related to high gas outlet temperature. If a catalyst, either because of its inherent characteristics or because of

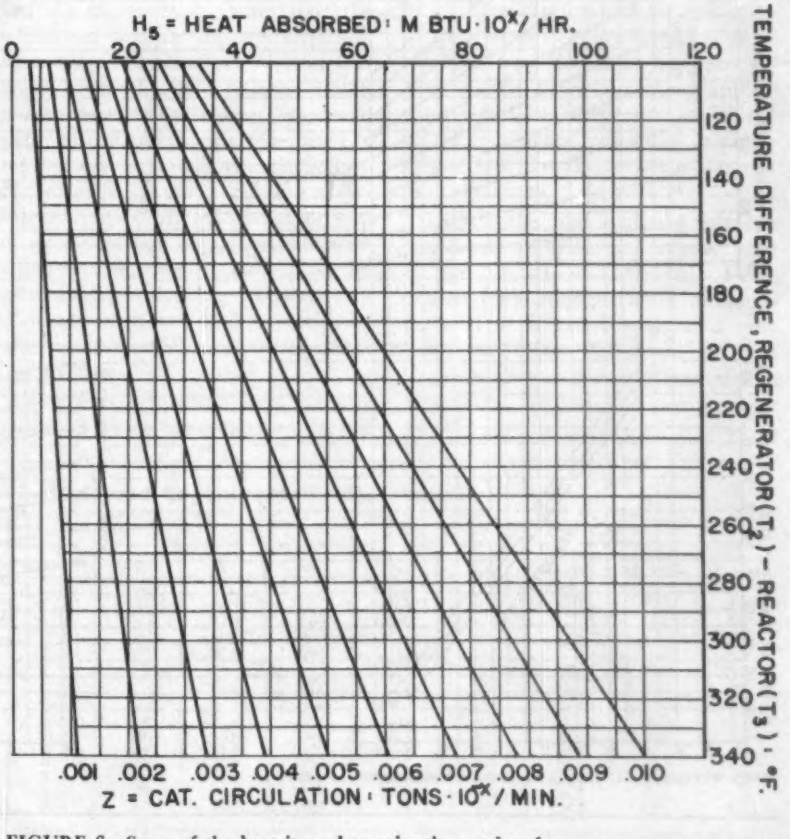

FIGURE 6—Some of the heat is used to raise the catalyst from reactor temperature to regenerator temperature.

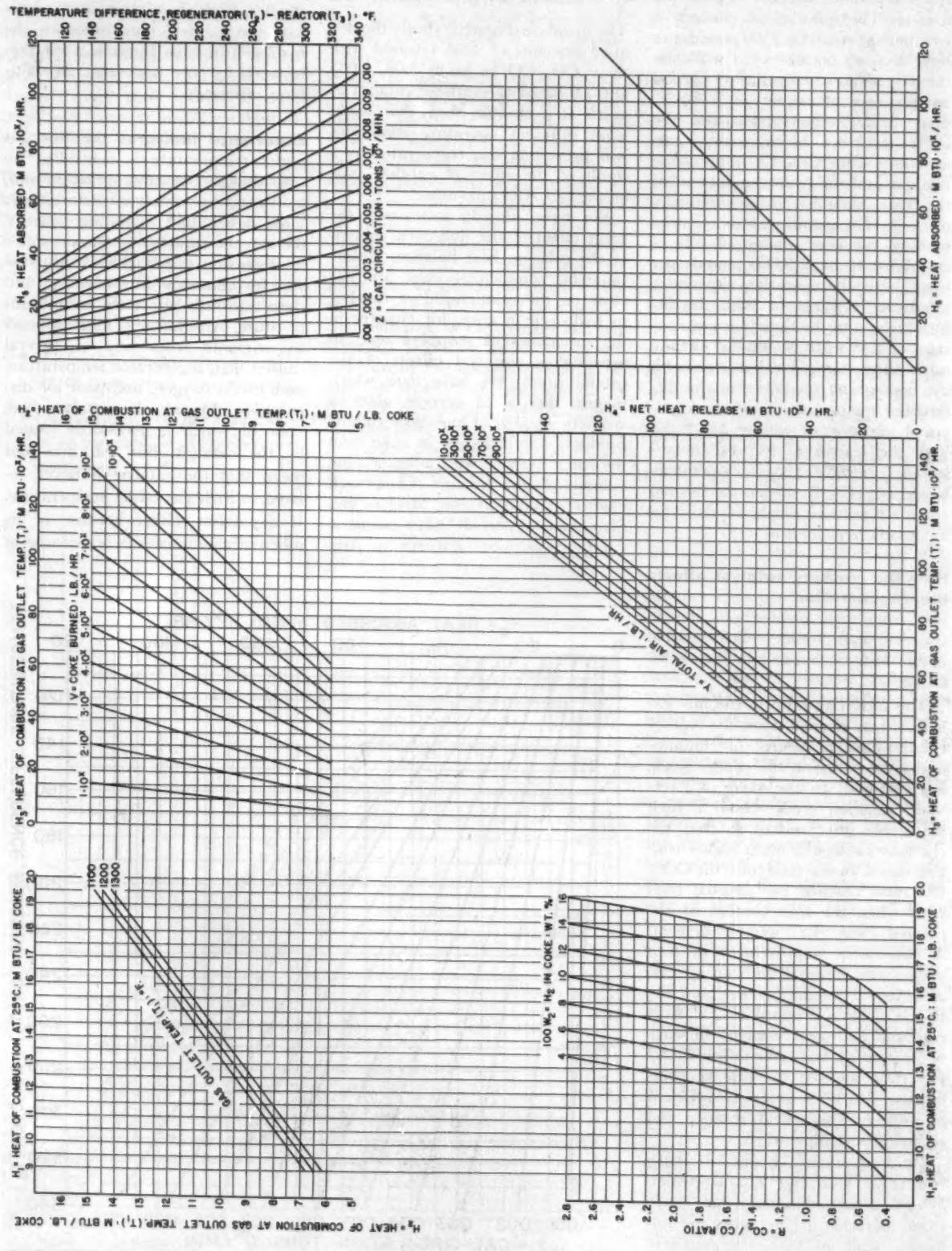
TEMPERATURE DIFFERENCE, REGENERATOR(T_2) – REACTOR(T_3), °F.
H_5 = HEAT ABSORBED, M BTU·10³/HR.
Z = CAT. CIRCULATION, TONS·10³/MIN.
H_4 = NET HEAT RELEASE, M BTU·10³/HR.
H_2 = HEAT OF COMBUSTION AT GAS OUTLET TEMP.(T_1), M BTU/LB. COKE
H_3 = HEAT OF COMBUSTION AT GAS OUTLET TEMP.(T_1), M BTU·10³/HR.
V = COKE BURNED, LB./HR.
V = TOTAL AIR, LB./HR.
H_1 = HEAT OF COMBUSTION AT 25°C., M BTU/LB. COKE
GAS OUTLET TEMP.(T_1), °F.
H_2 = HEAT OF COMBUSTION AT GAS OUTLET TEMP.(T_1), M BTU/LB. COKE
100 W_2 = H_2 IN COKE, WT. %
R = CO_2/CO RATIO

Figure 7—Easy Regenerator Heat Balances

maltreatment during use, possesses a slower regeneration rate, then the higher bed temperature and oxygen partial pressure needed to promote combustion on this particular catalyst can certainly result in higher gas outlet temperatures. But in this case, the higher outlet temperature is again the result of the action of the above regeneration variables.

Theoretical considerations show that the catalyst will affect regenerator heat balance by the effect of its inherent burning rate on the quantity of coke burned. But in practical operations, changes in operating conditions are made in order to hold the coke burned constant. Hence the influence of the catalysts is usually found in the changes in these conditions. A practical example might clarify this point. Assume a unit which burns 10,000 pounds of coke per hour, and has a catalyst circulation rate of 15 tons per minute. Then the coke lay-down represents 0.55 weight percent of catalyst, and this amount must be removed in the regenerator if operation is to continue. Now, if the regeneration rate were to decrease by as little as 1 percent, i.e., 100 pounds less coke were burned each hour with the same catalyst circulation, a coke build-up on the catalyst would take place at the rate of 0.0055 weight percent of catalyst per hour, or nearly 0.15 weight percent per day. Quite obviously, no unit would operate for many days under such a condition. As the coke on catalysts increases, operational changes are made to maintain original levels, and the quantity of coke burned remains the same. And this returns us to our major point: in continuous commercial operation, the effects of the coke burning rate of the catalyst will most frequently appear as changes in operating variables, not as the quantity of coke burned. In extreme cases where the catalyst has a very slow regeneration rate, the coke level on the regenerated catalyst may also increase.

Thus far we have examined four dependent heat balance variables and have determined that only CO_2/CO ratio and quantity of coke burned are affected by the catalyst. The independent variables, i.e., air rate, regenerator bed temperature and circulation rate can also be affected by the catalyst through its coke burning rate.

As in any other combustion reaction, the reaction rate for the burning of coke on catalyst is accelerated by an increase in the amount and partial pressure of available oxygen. Pansing has developed an equation[2] relating these and other variables to the specific reaction rate constant for fluidized catalyst. In our present context, the important point is that one of the symptoms of a catalyst having an inherently lower regeneration rate will be an increase in the excess oxygen in the flue gas for the same level of coke on regenerated catalyst. But the nomograph shows that the additional amount of air used will have only a small effect on heat balance. From the heat balance standpoint alone, most operations could easily afford the extra air required to regenerate a slow-burning catalyst. Nevertheless, prudent operation dictates the use of the minimum amount of excess oxygen commensurate with a reasonable level of carbon on regenerated catalyst to conserve air blower capacity and to minimize afterburning which can severely damage cyclones and catalyst.

The two remaining heat balance variables which are influenced by the coke burning rate of the catalyst are the bed temperature level and the catalyst residence time. The combustion reaction of coke is promoted by a higher regenerator bed temperature and by a longer residence time in the bed. Residence time can be partially controlled independently of any of the heat balance variables by varying the regenerator catalyst hold-up. The remaining control of the time variable lies in the catalyst circulation rate. But circulation rate and regenerator bed temperature are inter-related by heat balance, as Figure 6 has already indicated. Fortunately, the demands of the catalyst and those of heat balance are directionally consistent. If a catalyst should require a higher regeneration temperature to compensate for a slower coke burning rate, the normal mechanism by which the bed temperature could be raised would be a reduction in the catalyst circulation rate so that less heat would be removed from the regenerator. This lower circulation rate would itself tend to improve coke burning by increasing the residence time, thereby minimizing the temperature increase required. The increase in bed temperature and the reduction in catalyst circulation would tend to minimize any change in heat absorption, so that a new operating equilibrium could be obtained. Use of the entire nomograph will assist in establishing the actual new set of operating conditions.

During the past several years, we have received numerous reports that 25 percent alumina catalyst has caused high regenerator temperatures. This is true only in a very restricted sense. It would be just as accurate to blame plant design limitations, for the high temperature in this case is not at all related to

TABLE 1—Observed Regenerator Performance

MONTH	W_2	W_1	R	V	Y	Z	T_1	T_2	T_3	$H_4 \times 10^4$	$H_5 \times 10^4$	$K = \frac{H_4}{H_4 - H_5}$
August	.083	.917	.80	26.4	287	34.2	1100	1139	924	25.4	23.8	1.6
September	.085	.915	.79	27.0	292	32.5	1110	1148	921	27.0	24.8	2.2
October	.082	.918	.77	27.0	291	31.2	1090	1141	916	25.8	23.0	2.8
November	.083	.917	.72	27.7	291	32.6	1095	1146	915	25.1	25.0	0.1
December	.093	.907	.73	27.0	289	32.8	1094	1143	913	27.0	25.0	2.0
January	.073	.927	.74	27.3	289	33.2	1098	1146	919	24.8	25.5	—0.2
February	.080	.920	.79	23.7	263	31.9	1095	1112	915	22.0	20.5	1.5
March	.078	.922	.70	28.4	292	31.3	1110	1165	925	26.0	24.5	1.5
April	.080	.920	.64	28.8	292	32.1	1106	1159	923	26.0	24.7	1.3
May	.074	.926	.68	28.5	291	30.4	1107	1158	924	25.8	23.2	2.6
June	.077	.923	.74	27.3	291	33.8	1101	1138	923	26.0	25.0	1.0
July	.073	.927	.76	27.6	288	33.6	1100	1143	925	25.2	24.0	1.2
August	.075	.925	.67	28.0	286	32.9	1103	1147	923	26.2	25.0	1.2
September	.074	.926	.69	28.3	291	32.6	1105	1152	927	26.0	24.5	1.5
October	.083	.917	.70	27.6	292	33.6	1100	1152	932	26.0	24.5	1.5
November	.078	.922	.67	28.4	291	33.7	1095	1153	927	26.2	25.2	1.0

Statistical Data for "K"
Average = 1.43. Standard Deviation = 0.78. 95 percent Confidence Limits = ± 1.56, i.e. + 2.99 to — 0.13.

catalyst regeneration. Here is why! In many cases, 25 percent alumina catalyst has demonstrated a very high activity maintenance. In order to hold conversion to a reasonable level, it has therefore been necessary to reduce the severity of the other cracking reaction variables, among them the reactor bed temperature. The only means for reducing the reactor temperature in heat balance units is to lower the catalyst circulation rate. And since high alumina catalyst does not affect any of the regeneration variables, the heat balance nomograph makes clear that the lower catalyst circulation rate must increase the regenerator temperature. For example, a test run of 25 percent alumina catalyst in a unit of the Frontier Oil and Refining Company[3] resulted in an increase in circulating catalyst activity of 2 D+L even though the fresh catalyst addition rate was reduced. The reactor temperature was therefore decreased from 885 F. to 879 F., with a reduction in catalyst circulation rate from 14 to 12.5 tons per minute. And as a result, the regenerator bed temperature increased from 1120 F. to 1140 F. Now, when these data are applied to the graph in Figure 6 (or to the heat absorption section of the nomograph), it is seen that there was no net change in the heat absorbed by the catalyst in the regenerator. The increase in regenerator bed temperature was solely the result of operational changes in the reactor, brought about by the inflexibility of the plant in coping with a catalyst quality which is normally considered advantageous. In this particular example, the regenerator temperature change was not limiting. Other units were not as fortunate.

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IVEY

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SYMBOLS USED

W_1 — Weight fraction carbon in coke
W_2 — Weight fraction hydrogen in coke
R — CO_2/CO ratio in flue gas
V — Coke burned: M Lb./Hr.
Y — Total air to regenerator: M Lb./Hr.
Z — Catalyst circulation rate: Tons/Min.
T_1 — Gas outlet temperature: °F.
T_2 — Regenerator bed temperature: °F.
T_3 — Reactor bed temperature: °F.
H_1 — Heat of combustion of coke at 25 C. (77 F.): M BTU/Lb. Coke.
H_2 — Heat of combustion of coke at gas outlet temperature (T_1): M BTU/Lb. Coke
H_3 — Heat of combustion of coke at gas outlet temperature (T_1): M BTU/Hr.
H_4 — Heat of combustion at gas outlet temperature (T_1) corrected for excess air: M BTU/Hr.
H_5 — Heat absorbed by circulating catalyst
$H_4 - H_5 = K$ = Radiation loss constant

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[2] Pansing, W. F., "Regeneration of Fluidized Cracking Catalysts," *American Institute of Chemical Engineers Journal*, Vol. 2, No. 1, p. 71.

[3] Wunderlich, O. A., Prichard, J. J., and Ivey, F. Emerson, "High Alumina Catalyst Gets High Score in Tests," *Oil and Gas Journal*, Oct. 17, 1955, p. 121.

APPENDIX—HEAT BALANCE EQUATION

Figure 2, Heat of Combustion of Coke

$$H_1 = 3.96 + 10.15\ A + 57.52W_2 - 10.15W_2A$$

$$\text{where } A = \frac{R}{R+1}$$

Figure 3, Heat Absorbed by Combustion Gases

$$H_2 = H_1 - \left[\frac{(T_1 - 77)\ (1.445\ A - 1.445\ AW_2 + 9.394W_2 + 1.729)}{1000} + 1.052\ W_2\right]$$

Figure 4, Effect of Coke Burned on Heat Release

$$H_3 = H_2\ V$$

Figure 5, Effect of Air Volume on Heat Release

$$H_4 = H_3 - \left\{\frac{T - 77}{1000}\left[0.245Y - V\ (1.409A + 7.043\ W_2 - 1.409AW_2 + 1.409)\right]\right\}$$

Figure 6, Effect of Catalyst Circulation on Heat Absorbed

$$H_5 = 32.4\ (T_2 - T_3)\ Z$$

Constants, at Standard Conditions of 25 C. (77 F.), 1 Atm.

Gross heat of combustion of C to CO_2: M BTU/Lb. mol reactant	169.293
Gross heat of combustion of C to CO: M BTU/Lb. mol reactant	47.548
Gross heat of cumbustion of H_2 to H_2O: M BTU/Lb. mol reactant	122.971
Heat of vaporization of water: M BTU/Lb.	1052

Constants, mean, over temperature range 77 F. to average gas outlet temperature

Heat capacity of CO_2: BTU/Lb. mol/°F	11.0
Heat capacity of CO: BTU/Lb. mol/°F	7.2
Heat capacity of N_2: BTU/Lb. mol/°F	7.2
Heat capacity of H_2O (vapor): BTU/Lb. mol/°F	8.7
Heat capacity of air: BTU/Lb. mol/°F	7.1
Heat capacity of catalyst: BTU/Lb./°F	0.27

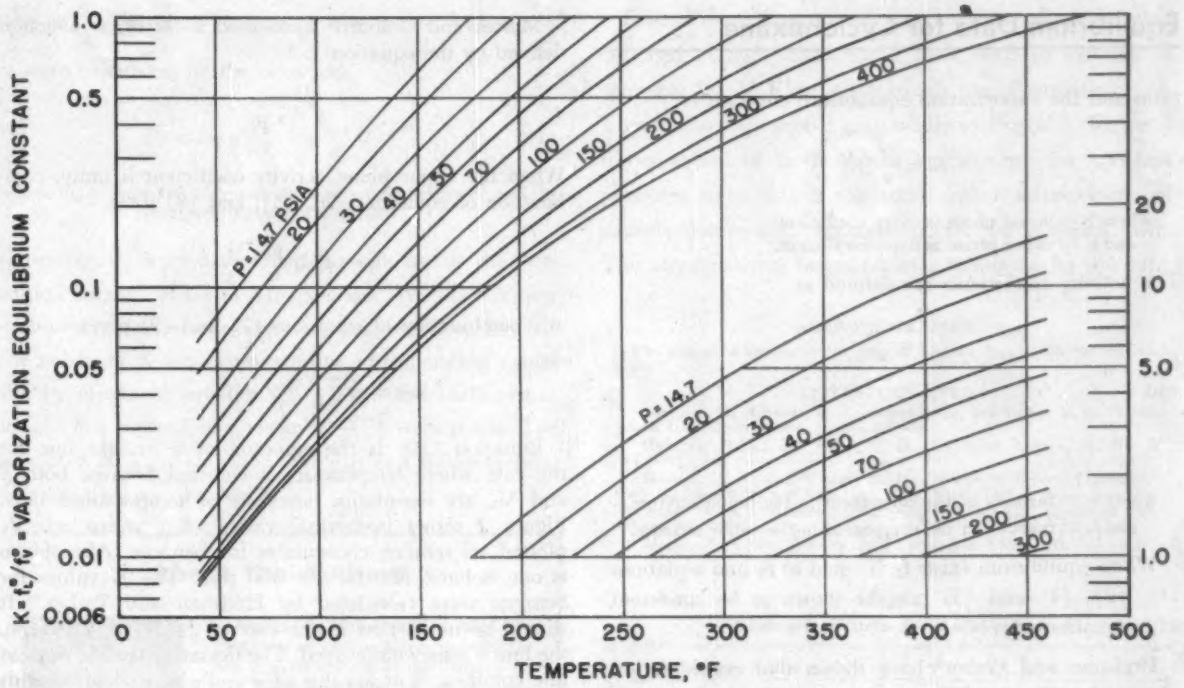

FIGURE 1—The properties of cyclohexane were examined in order to calculate the equilibrium constants for this compound.

Equilibrium Data Now Available For Cyclohexane

Here is a practical method for calculating the vaporization equilibrium constants for pure components. Data for cyclohexane are presented to show how the method works.

Dwight S. Hoffman, University of Idaho, Moscow, Idaho
and James H. Weber, University of Nebraska, Lincoln, Neb.

IF YOU NEED vaporization equilibrium constants for pure components, particularly cyclohexane, you will find the calculation method and data presented here of considerable use. A practical method for the evaluation of vaporization equilibrium constants is demonstrated and data for cyclohexane over the temperature range 40 F. to 460 F. and pressures up to 400 psia are presented in Figure 1 and in tabular form.

The vaporization equilibrium constant for a pure component, which is equal to

$$K = \frac{f^\circ_L}{f^\circ_V} \qquad (1)$$

where f°_L = the fugacity of the pure liquid at the temperature and pressure of the system
and f°_V = the fugacity of the pure vapor at the temperature and pressure of the system,

may be used in conjunction with the liquid and vapor phase activity coefficients which the component displays in a mixture to determine the important vaporization equilibrium ratio. The vaporization equilibrium ratio is defined as follows:

$$K' = \frac{y}{x} \qquad (2)$$

where y = mole fraction of component in vapor phase
and x = mole fraction of component in liquid phase.

The relationship between the vaporization equilibrium

ratio and the vaporization equilibrium constant is

$$K' = \frac{\gamma}{\varphi} K \qquad (3)$$

where γ = liquid phase activity coefficient
and φ = vapor phase activity coefficient.

The activity coefficients are defined as

$$\gamma = \frac{\bar{f}_L}{x f^\circ_L} \qquad (4)$$

and

$$\varphi = \frac{\bar{f}_V}{y f^\circ_V} \qquad (5)$$

where $\bar{f}_L$ = fugacity of the component in the liquid mixture
and $\bar{f}_V$ = fugacity of the component in the vapor mixture.

When equilibrium exists $\bar{f}_L$ is equal to $\bar{f}_V$ and equations (1), (2), (4) and (5) may be shown to be consistent with equation (3).

Hoffman and Weber[2] have shown that consideration of equation (3) for the case where $\varphi = 1$ and the following equation of Benedict, et al.[1]

$$\ln \frac{y}{x} = \ln \frac{P_V}{\pi} + \frac{(\pi - P_V)(V_L - \beta)}{RT} + \ln \gamma \qquad (6)$$

gives

$$K = e^{\frac{(\pi - P_V)(V_L - \beta)}{RT}} \frac{P_V}{\pi} \qquad (7)$$

where π = pressure of the system in equilibrium,
T = absolute temperature of the system at equilibrium,
P_V = vapor pressure of the component concerned at the temperature of the system,
V_L = liquid molar volume of the component concerned at the temperature and pressure of the system,
β = second virial coefficient for the component concerned at the temperature and pressure of the system,
and R = the gas law constant.

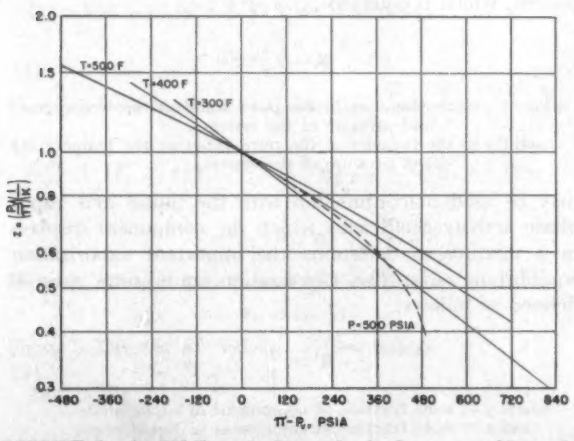

FIGURE 2—At 500 F. and above, the isotherms on this semilog plot for benzene become curved.

Mertes and Colburn[5] have used a factor, z, which is defined by the equation

$$\gamma = z \frac{\pi_Y}{P_V x} \qquad (8)$$

When the vapor phase activity coefficient is unity, combination of equations (2), (3), and (8) gives

$$K = \frac{P_V}{\pi} \frac{1}{z} \qquad (9)$$

and combination of equations (7) and (9) gives

$$\ln z = \frac{\beta - V_L}{RT}(\pi - P_V) \qquad (10)$$

Equation (10) is the equation of a straight line for the case where temperature is constant because both β and V_L are essentially functions of temperatures only. Figure 2 shows isothermal values of z versus $\pi - P_V$ plotted on semilog coordinates for benzene. Also shown is one isobaric line for $P = 500$ psia. The K values for benzene were calculated by Hoffman and Weber.[2] It should be noted that in the case of the 500 F. isotherm, the line is somewhat curved. The deviation from a straight line commences at a value of $\pi - P_V$ which corresponds to a total pressure of 500 psia. In the case of the isotherms for 400 F. and 300 F. no deviation from a straight line is observed below total pressures of 800 psia. Deviation from the straight line behavior predicted by equation (10) is expected at high pressures because it is based upon an equation of state containing only the second virial coefficient, and such equations do not accurately predict vapor phase behavior at high pressures. From the benzene data, it may be expected that in general a plot of ln z versus $\pi - P_V$ will give a straight line if the pressures are less than a reduced pressure of approximately 0.6.

Use was made of the fact that isothermal plots of ln z versus $\pi - P_V$ are straight lines up to pressures of at least 400 psia in the evaluation of equilibrium vaporization constants for cyclohexane. Values of K at four pressures were calculated using equation (1) for isotherms at 40 F., 100 F., 160 F., 220 F., 280 F., 340 F., 400 F., and 460 F. Values for f°_V were evaluated by use of the generalized

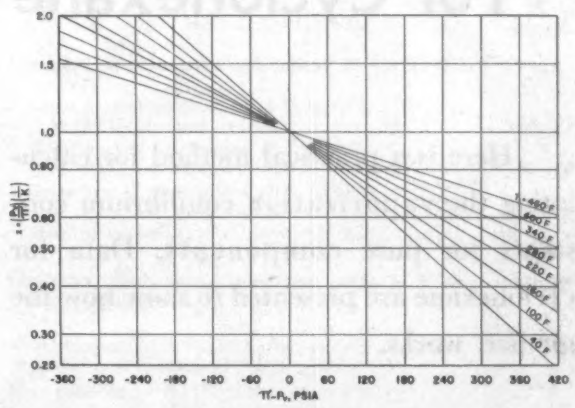

FIGURE 3—The semilog plot of each isotherm for cyclohexane was linear. This fact was used to calculate the vapor equilibrium constants.

chart of $\frac{f}{\pi}$ values of Hougen and Watson.[3] Values for f°_L were calculated by the equation

$$f^\circ_L = f_{PV}\, e^{\frac{V_L}{RT}(\pi - P_V)} \qquad (11)$$

where f_{PV} = fugacity of vapor at a given temperature and its corresponding vapor pressure.

Values for V_L were determined through use of the "expansion factor" chart of Hougen and Watson.[3] Vapor pressure data for cyclohexane were obtained from Lange.[4] The values of K were converted to corresponding values of z by means of equation (9). Then the isothermal straight line plots of ln z versus $\pi - P_V$ were made. The calculated data are shown in Table 1, and the isothermal plots are shown in Figure 3.

From Figure 3 values of z at constant pressures were obtained. These values for z were used to evaluate a complete set of K values through use of equation (9). These values are shown graphically in Figure 1. Figure 1 shows values of ln K versus temperature for constant pressures since this is the most useful arrangement of vaporization equilibrium constants for use in design work. The accompanying box contains a tabulation of the data.

ACKNOWLEDGMENT

The authors acknowledge the help of Y. John Kaku with the calculations.

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TABLE 1

Summary of Data for Cyclohexane

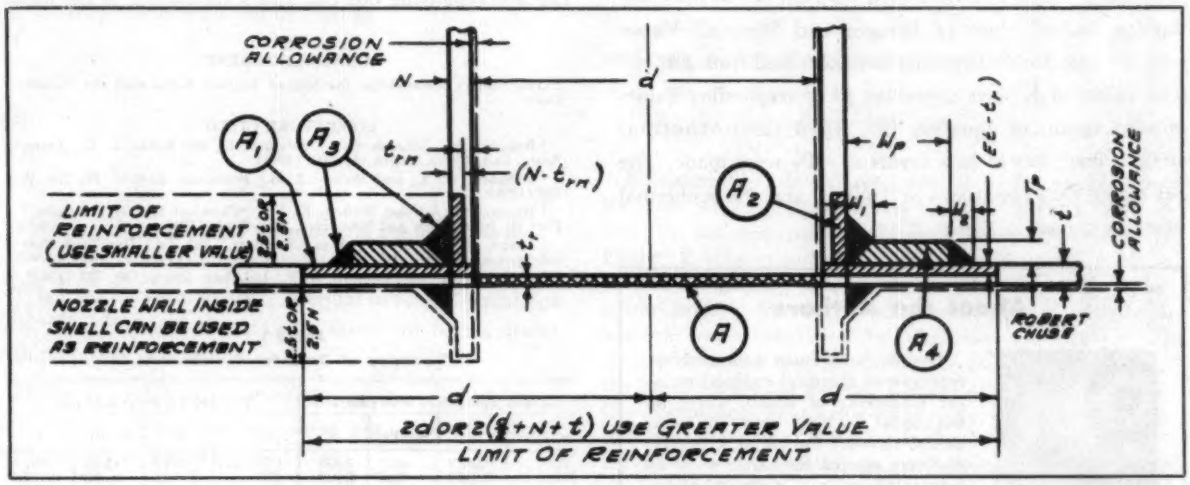
T = 40F., P_V = 0.90 psia				T = 100 F., P_V = 3.35 psia			
π	K	$\pi - P_V$	z	π	K	$\pi - P_V$	z
50.....	0.0212	49.1	0.851	50.....	0.0773	46.65	0.867
100.....	0.0126	99.1	0.714	100.....	0.0448	96.65	0.747
350.....	0.0082	349.1	0.311	350.....	0.0265	346.65	0.360
400.....	0.0079	399.1	0.284	400.....	0.0259	396.65	0.323
T = 160 F., P_V = 11.0 psia				**T = 220 F., P_V = 28.2 psia**			
π	K	$\pi - P_V$	z	π	K	$\pi - P_V$	z
50.....	0.242	39.0	0.906	50.....	0.594	21.8	0.950
100.....	0.138	89.0	0.798	100.....	0.330	71.8	0.854
350.....	0.0745	339.0	0.422	350.....	0.160	321.8	0.503
400.....	0.0735	389.0	0.374	400.....	0.159	371.8	0.444
T = 280 F., P_V = 62 psia				**T = 340 F., P_V = 120 psia**			
π	K	$\pi - P_V$	z	π	K	$\pi - P_V$	z
50.....	1.212	—12.0	1.02	50.....	2.155	—70.0	1.114
100.....	0.667	38.0	0.929	100.....	1.170	—20.0	1.027
350.....	0.308	288.0	0.575	350.....	0.490	230.0	0.699
400.....	0.298	338.0	0.522	400.....	0.471	280.0	0.636
T = 400 F., P_V = 207 psia				**T = 460 F., P_V = 340 psia**			
π	K	$\pi - P_V$	z	π	K	$\pi - P_V$	z
50.....	3.360	—157.0	1.231	50.....	4.770	—290.0	1.425
100.....	1.790	—107.0	1.155	100.....	2.520	—240.0	1.349
350.....	0.725	143.0	0.815	350.....	0.975	10.0	0.996
400.....	0.678	193.0	0.763	400.....	0.900	60.0	0.945

Here are vaporization equilibrium constants for cyclohexane . . .

T. °F.	PRESSURE, psia (Vaporization Temperatures)										
	14.7 (175)	**20 (197)**	**30 (224)**	**40 (244)**	**50 (262)**	**70 (289)**	**100 (323)**	**150 (365)**	**200 (396)**	**300 (443)**	**400 (480)**
40	0.064	0.048	0.033	0.026	0.021	0.016	0.013	0.0098	0.0087	0.0081	0.0079
100	0.236	0.175	0.121	0.094	0.077	0.058	0.045	0.0345	0.030	0.027	0.026
160	0.755	0.564	0.384	0.297	0.242	0.183	0.138	0.103	0.089	0.076	0.073
220	1.86	1.38	0.943	0.720	0.594	0.442	0.330	0.245	0.204	0.168	0.159
280	3.63	2.84	1.93	1.49	1.212	0.894	0.667	0.487	0.402	0.325	0.298
340	6.91	5.11	3.46	2.66	2.155	1.587	1.17	0.838	0.680	0.541	0.471
400	10.65	7.85	5.35	4.08	3.36	2.42	1.79	1.27	1.01	0.782	0.678
460	15.42	11.40	7.64	5.86	4.77	3.47	2.52	1.79	1.43	1.08	0.900

Reinforced Opening Design Simplified

Use this data sheet for fast and accurate calculations when working with nozzles in a shell or head.



Robert Chuse, Leonia, N. J.

Area of reinforcement required

$$A = dt_r = \ldots\ldots$$

Area of reinforcement available ($A_1 + A_2 + A_3 + A_4$*):

Area of excess thick., in shell or head

$$A_1 = (Et - t_r)\, d = \ldots\ldots$$

(Use greater value)

$$\text{or } A_1 = 2\,(Et - t_r)\,(t + N) = \ldots\ldots$$

Area of excess thick., in nozzle wall

$$A_2 = 2\,(2.5N)^{\ddagger}(N - t_{rn}) = \ldots\ldots$$

(Use smaller value)

$$\text{or } A_2 = 2\,(2.5t)^{\ddagger}(N - t_{rn}) = \ldots\ldots$$

Cross section area of welds

$$A_3 = 2\left(\frac{(W_1)^2 + (W_2)^2}{2}\right) = \ldots\ldots$$

Area in pad*

$$A_4 = 2\,W_p\,T_p = \ldots\ldots$$

$$\text{Total area available} = \ldots\ldots$$

‡ If reinforcing pad is used factors become $(2.5N + T_p)$ and $(2.5t + T_p)$ respectively.

* if needed

NOTATION

Shell or Head Data:

- t = Actual thickness of shell or head (minus corrosion)
- t_r = Calculated thickness of shell or head
- $Et - t_r$ = Excess thickness in shell or head

Nozzle Data:

- P = Pressure
- S = Allowable stress
- r = Inside radius of nozzle
- E = Joint efficiency
- $t_{rn} = \dfrac{Pr}{SE - .6\,P}$
- N = Actual thickness of nozzle (minus corrosion)
- t_{rn} = Calculated thickness of nozzle
- $N - t_{rn}$ = Excess thickness in nozzle
- T_p = Thickness of pad

ACKNOWLEDGMENT

From a privately circulated book by Robert Chuse entitled "The Unfired Pressure Vessel Code Simplified," upon which the author holds the copyright.

About the Author

Robert Chuse graduated from Pennsylvania State Nautical School in 1930, where he studied Marine Engineering. After graduation he worked as an engineering officer in the U. S. Merchant Marine. In 1936 he came ashore and at night attended City College of New York and studied metallography at Stevens Institute of Technology in Hoboken, N. J. He later taught stationary engineering at Mondell Institute, New York.

Since 1941 he has been reviewing designs and inspecting pressure vessels and boilers built according to the ASME Codes.

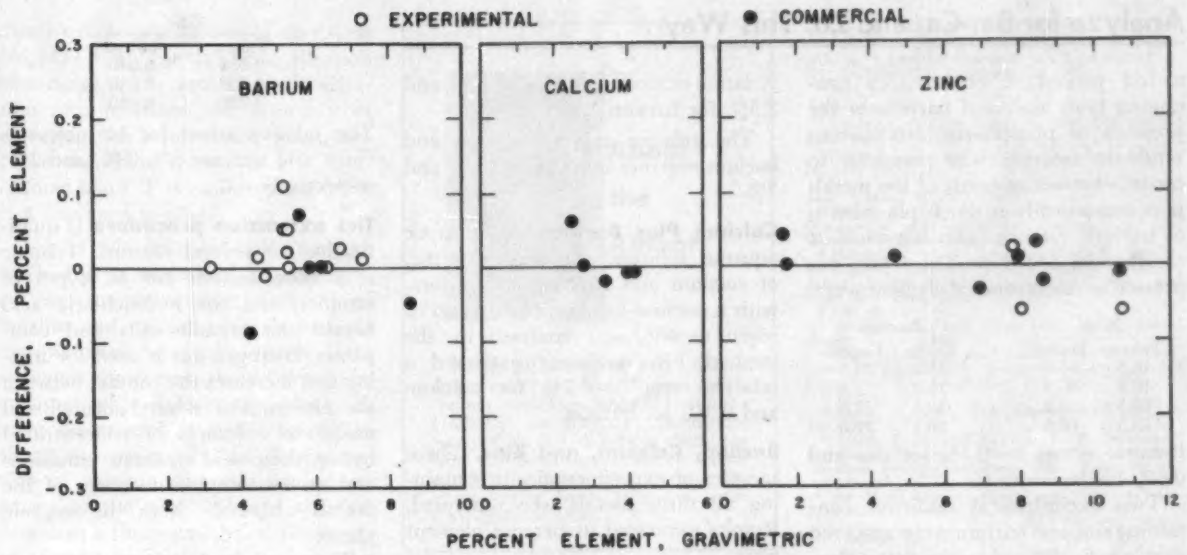


FIGURE 1—The method is accurate enough to use as a referee and yet rapid enough to apply to quality control.

Analyze for Ba, Ca, and Zn This Way

A rapid and accurate method is described to help you determine barium, calcium, and zinc in lube additives and oils.

Ralph J. Bertolacini
Standard Oil Company (Indiana)
Whiting, Ind.

AN EXTRACTION-TITRATION method has been developed for the determination of barium, calcium, and zinc, singly or in combination, in lubricating-oil additives and blended oils. It is rapid enough to apply to quality control in manufacturing, and accurate enough to use as a referee.

With this method, eight samples can be analyzed per day by one person, whereas conventional methods take two or three days. Because it is simple, the method can be handled by non-technical personnel. It gives accuracies equivalent to those obtained with conventional chemical oxidation and gravimetric methods. Furthermore, it can be extended to used oils if the history is known and if interfering metals can be masked or separated.

The extraction is with hydrochloric acid and the titration is complexometrically with tetrasodium ethylenediaminetetracetate solution. When zinc and barium or calcium and barium are present, two extractions are necessary. In the first extraction, both metals are determined and, in the second, barium sulfate is precipitated and the zinc or calcium is titrated complexometrically. When all three are present, barium is determined gravimetrically, zinc is separated from calcium as zinc sulfide, and calcium and zinc are determined complexometrically.

The method was tested on synthetic aqueous solutions, experimental and commercial additives, and blended oils. These samples covered the amounts in which the metals and phosphorus are normally found. All referee analyses were performed by standard gravimetric methods[24] for the individual metals on the aqueous solutions resulting from chemical oxidation of the samples.

Single Metals. The precision of replicate analyses of three commercial additives each containing a single metal is shown in the following table.

Barium	Calcium	Zinc
8.00%	4.59%	8.78%
8.01	4.59	8.78
8.00	4.59	8.78
8.00	4.59	8.76
8.04	4.62	8.72
8.02	4.60	8.72
8.00	4.59	8.76
8.00	4.62	8.77
Av. 8.01	4.60	8.76
Dev. 0.023	0.031	0.026

Figure 1 shows the accuracy of the method for the analysis of additives containing a single metal. The relative errors for barium, calcium, and zinc are 0.7%, 0.8%, and 0.4%, respectively.

Zinc Plus Barium. To test the titri-

metric procedure on samples containing both zinc and barium in the presence of phosphorus, an aqueous synthetic solution was prepared to contain known amounts of the metals plus one-seventh as much phosphorus as barium. Such a ratio is typical of commercial additives. The results expressed as milligrams of element were:

Zinc		Barium	
Taken	Found	Taken	Found
46.3	46.0	75.2	75.5
46.3	46.3	75.2	75.0
18.5	18.5	30.1	29.6
18.5	18.5	30.1	29.8

Relative errors are 0.1% for zinc and 0.8% for barium.

Two experimental additives containing zinc and barium were analyzed gravimetrically and by the extraction-titration method. The results expressed as percent element were:

Zinc	
Extraction	Gravimetric
1.03	1.03
0.54	0.50

Barium	
Extraction	Gravimetric
6.50	6.80
8.26	8.20

Relative errors are 4.0% for zinc and 2.5% for barium.

The relative errors for zinc and barium together in an oil are 4% and 7%.

Calcium Plus Barium. A synthetic aqueous solution containing 5.0 mg. of calcium and 75.2 mg. of barium, with a barium-to-phosphorus ratio of seven to one, was analyzed by the method. Five analyses possessed a relative error of 0.2% for calcium and 0.3% for barium.

Barium, Calcium, and Zinc. Three samples of experimental oils containing all three metals were analyzed. Results expressed as percent element were:

Barium	
Taken	Found
0.78	0.80
0.26	0.27
0.52	0.54

Calcium	
Taken	Found
0.16	0.13
0.08	0.08
0.08	0.08

Zinc	
Taken	Found
0.039	0.040
0.029	0.030
0.030	0.030

The relative errors for barium, calcium, and zinc are 3%, 5%, and 2%, respectively.

The extraction procedure is quantitative for several reasons. Toluene is a good solvent for all types of samples, and the hydrochloric acid breaks the organic salts and complexes. Nitrogen gas is used for mixing and increases the contact between the phases. The n-butyl alcohol and moderate volumes of concentrated hydrochloric acid eliminate emulsions and assure complete recovery of the metal chloride from the organic phase.

The prescribed sequence of titrations is important because it eliminates several disadvantages of ordinary complexometric titrations. Small amounts of phosphate extracted by the hydrochloric acid may form insoluble phosphates. When the metal is titrated with Na_4EDTA by conventional methods, the end point fades because these phosphates re-

WHY AND HOW TO USE THIS METHOD

TODAY'S IMPROVED motor oils largely owe their high quality to the presence of added dispersant-detergents and inhibitors. Such additives are often organic salts of barium, calcium, or zinc. Common detergents are sulfonates, phenates, and phosphonates; common inhibitors include dithiophosphates, carbamates, and phenates.

Analysis of metals can be performed directly on the oil or indirectly after the metals have been separated from the organic matter. Such direct methods as spectrography,[15] flame-photometry,[14,22] and X-ray fluorescence[6] are rapid in routine use, but they need special equipment and depend on chemical referee methods for calibration.

Indirect analysis depends on the separation of the metals from the oil by destroying the organic matter by chemical oxidation,[1] ashing,[2] or extracting with aqueous acid.[13,19] Chemical oxidation, which is usually carried out with nitric and sulfuric acids, is slow and requires continuous attention for large amounts of oil; the sample also may be lost because the reaction mixture tends to spatter. Ashing is rapid, but we have found that some metals may be lost by volatilization, and that sulfur or phosphorus may lead to acid-insoluble salts. Extraction is quantitative, is rapid, needs little attention, and converts the metals to water-soluble salts.

Extracted metals can be determined by gravimetry or titrimetry. Gravimetric methods for barium, calcium, and zinc[9,24] are laborious, and few of them include separations of mixtures.[9,21] Separation of barium and calcium nitrates with nitric acid[20] is not quantitative; with perchloric acid,[17] it is time consuming. Zinc can be separated from the alkaline earths with ammonium sulfide,[8] but the alkaline earths remaining can not be completely separated from each other. Titration of barium with sulfate and such indicators as tetrahydroxyquinone[22] and sodium rhodozonate[16] can not be used in the presence of phosphate or other alkaline-earth metals. Titrations with carbonate[4] and chromate[10] also have serious interferences. The oxalto-permanganate titration for calcium[11] cannot be used in the presence of barium or zinc. Titration of zinc with 8-hydroxyquinoline[7] or ferrocyanide[12] requires lengthy separation.

Complexometric titrations[18] have replaced many classical titrimetric and gravimetric methods. They depend on the formation of a stable cation-chelate complex and on the difference in color between a cation-indicator complex and the uncomplexed indicator. The cation to be determined is titrated with a chelating agent, such as ethylenediaminetetracetic acid, in the presence of a suitable indicator, in solutions buffered at the pH where both cation-chelate and cation-indicator complexes are stable. At the end point, the chelating agent releases the indicator from the cation-indicator complex and produces a sharp color change.

The extraction apparatus is simple to construct and the reagents are easily prepared from commercial materials. The conventional stopcock of a tetraethyllead extractor[3] is replaced with a three-way stopcock. A source of nitrogen is connected to the stopcock to permit the passage of gas through the flask.

To carry out the extraction, weigh into a tared 20-ml. beaker enough sample to contain 40-50 mg. of the metal present in the largest amount. Add 10 ml. of toluene, and heat gently on a hot plate with stirring until the sample is completely dissolved. Transfer to the flask of the extractor through the dropping funnel. Rinse the glassware with 40 ml. of toluene and transfer it to the flask. Add 50 ml. of 6 N hydrochloric acid to the flask, and close the stopcock on the dropping funnel. Adjust the three-way stopcock so that nitrogen bubbles freely through the solution. Adjust the heat and the nitrogen flow so that there is at no time a steady stream of condensate from the condenser, and reflux for 45 minutes.

Turn off the heat and add 20 ml. of n-butyl alcohol. Allow the contents to cool, then shut off the nitrogen gas. Drain the lower layer into a 250-ml. beaker. Add 50 ml. of distilled water to the flask, and reflux the water and toluene for five minutes, with regulation of the flow of nitrogen as before. Turn off the heat and add 20 ml. of n-butyl alcohol. Allow the mixture to cool, then shut off the nitrogen. Drain the lower layer into the 250-ml. beaker. Repeat the refluxing and extraction with water. If emulsions form, they can be broken by adding 20 ml. of concentrated hydrochloric acid after refluxing.

The standard solutions are prepared from commercial materials as follows:

Tetrasodium ethylenediaminetetraacetate standard (Na_4EDTA): Dissolve 45 g. of the disodium salt and 8 g. of sodium hydroxide in water and dilute to 2 liters. Standardize against primary standard calcium carbonate.

Zinc Standard: Dissolve 4 g. of pure

dissolve slowly. Addition of an excess Na_4EDTA before the back titration eliminates these errors. Back titration also increases the accuracy of detecting the equivalence point, because the color change of the Eriochrome black T is easier to see when it is from red to blue.

Use of two different buffers in the method is a matter of convenience. In the complexometric titration of barium and calcium, metals such as magnesium or zinc, which form stronger complexes than barium or calcium with Eriochrome black T, must be present in order to obtain sharp end points. In the determination of calcium, the addition of an excess of the zinc standard solution produces a sharp end point. However, in the determination of barium, the author has found that magnesium must also be present. It is simpler to use a buffer containing magnesium for titrating barium, than to use an Na_4EDTA solution containing magnesium.

Other dyes have been employed for titrating these metals with Na_4EDTA. Murexide has been proposed for titrating calcium[20] and phthalein purple has been used for barium.[5] The Eriochrome black T, however, is advantageous because the analyst need familiarize himself with only one color change.

About the Author

Ralph J. Bertolacini is a chemist doing catalysis research and development work Standard Oil Company (Indiana) in Whiting. Bertolacini received his B.S. degree in chemistry from the University of Rhode Island in 1949, and his M.S. degree also in chemistry from Michigan State University in 1957.

ACKNOWLEDGMENT

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acid-washed zinc metal in 25 ml. of 6N hydrochloric acid and dilute with water to 1 liter. Standardize against the Na_4EDTA solution.

Indicator: Grind and mix thoroughly 25 g. of sodium chloride with 0.025 g. of Eriochrome black T.

Buffer A (pH 10): Add 8.25 g. of ammonium chloride to a 1-liter flask containing 113 ml. of concentrated ammonium hydroxide and dilute to volume with water.

Buffer B (pH 10): Dissolve 8.25 g. of ammonium chloride in a 1-liter flask containing 500 ml. of water. Add 113 ml. of concentrated ammonium hydroxide and dilute to 800 ml. with water. Dissolve 0.1 g. of magnesium chloride in 10 ml. of water, add 10 ml. of buffer A and about 0.1 g. of indicator. Titrate with Na_4EDTA to a pure blue end point. Add the titrated solution to the liter flask and dilute to volume with water (26).

20% Ammonium Sulfate: add 200 g. of the salt to a 1-liter flask and dilute to volume with water.

The titration of the extract material is tailored to the combinations of metals present. The method of titration for each combination is suggested in the following paragraphs:

Single Metals. Evaporate the aqueous-acid extract nearly to dryness, and add 25.0 ml. of the standard Na_4EDTA solution. Adjust the pH to about 9 to 10 with ammonium hydroxide, add 100 ml. of water and 20 ml. of buffer A, and stir until the residue dissolves. Then add about 0.4 g. of indicator, followed by a measured amount of standard zinc solution in excess, so that the mixture turns deep red. To determine barium, add 10 ml. of buffer B and titrate the excess zinc with the standard Na_4EDTA solution to a pure blue end point. To determine either calcium or zinc, proceed in the same manner except do not add buffer B.

Zinc Plus Barium. Evaporate the aqueous-acid extracts from two extractions to about 10 ml., and dilute one to 200 ml. with distilled water. To determine zinc, heat the solution nearly to boiling and add 10 ml. of the ammonium sulfate solution. Cool to room temperature and adjust to about pH 9 to 10 with ammonium hydroxide. Add 20 ml. of buffer A and about 0.4 g. of indicator, and a measured amount of the standard zinc solution in excess so that the solution turns deep red. Titrate the excess zinc with the Na_4EDTA solution to a pure blue end point.

To determine zinc plus barium, add 25.0 ml. of the standard Na_4EDTA solution to the second sample. Adjust the pH to about 9 to 10 with ammonium hydroxide, add 100 ml. of water, 20 ml. of buffer A, and stir until the residue dissolves. Add 0.4 g. of indicator, followed by a measured excess of standard zinc solution so that the solution turns deep red. Titrate the excess zinc with the Na_4EDTA solution to a pure blue end point.

Calcium Plus Barium. To determine calcium, add 20 ml. of the ammonium sulfate solution to the aqueous-acid extract, filter off the precipitated barium sulfate, and evaporate the filtrate to about 10 ml. Add 25.0 ml. of the Na_4EDTA solution, adjust the pH to about 9 to 10 with ammonium hydroxide, and dilute to 200 ml. with water. Add 20 ml. of buffer A, 0.4 g. of indicator, and a measured amount of standard zinc solution in excess so that the solution turns deep red. Titrate the excess zinc with the Na_4EDTA solution to a pure blue end point.

To determine calcium plus barium, evaporate another aqueous-acid extract to about 10 ml., then add 25.0 ml. of Na_4EDTA solution and proceed as before. Calculate barium from the difference in the two titrations.

Barium, Calcium and Zinc. To determine barium, add 20 ml. of the ammonium sulfate solution to the hot aqueous-acid extract and digest for two hours. Filter off the precipitated barium sulfate, wash the precipitate with hot water, and weigh the barium as barium sulfate[13].

To determine calcium, evaporate the filtrate from the barium determination to about 10 ml., add 2 g. of solid ammonium chloride, and dilute to 100 ml. with distilled water. Neutralize the solution with ammonium hydroxide, and add 2 ml. of a saturated ammonium sulfide solution to precipitate zinc as zinc sulfide. Digest on a steam bath for two hours, filter, and wash the precipitate with 2% ammonium chloride solution. To the filtrate add 25.0 ml. of the Na_4EDTA solution, 20 ml. of buffer A, 0.4 g. of indicator, and a measured amount of the standard zinc solution in excess so that the solution turns deep red. Titrate the excess zinc with Na_4EDTA to a pure blue end point.

To determine zinc, dissolve the precipitated zinc sulfide on the filter paper with 5 ml. of hot concentrated hydrochloric acid, and wash the solution through the filter paper with water into a beaker. Evaporate to about 10 ml. and dilute to 200 ml. with distilled water. Adjust to about pH 9 to 10 with ammonium hydroxide, add 20 ml. of buffer A and 0.4 g. of indicator, and a measured amount of the standard zinc solution in excess so that the solution turns deep red. Titrate the excess zinc with Na_4EDTA to a pure blue end point. ##

Know Your Asphalts–Part 6

Here Are More Asphalt Tests

E. J. Barth
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New York City

THE RELATION of various emperical tests to asphalt quality is, in many cases, rather nebulous. The characteristics that contribute to asphalt quality are best determined and understood by use of these tests. Here are more test methods and what should be expected from them.

Flash and Fire Points are determined in the open Cleveland flash cup according to A.S.T.M. procedure. Naphthenic crude asphalts show a somewhat lower flash than materials from much higher boiling paraffinic or mixed based crude origin. Flash points are usually 600 F. or over; with some Venezuelan asphalts from very heavy crude as low as 560 F.

Carbon Disulfide and Carbon Tetrachloride Solubility indicates the purity of an asphalt or the presence of inert, useless non-adhesive matter. Properly reduced oil asphalts (without cracking) are over 99 percent soluble in disulfide. This test detects natural asphalts, e.g., Trinidad (54-56.5 percent soluble); Bermudez (90-95 percent soluble); Cuban (90 percent plus soluble). Upon fluxing to paving grade penetration the solubility of these asphalts increases.

Using pure carbon tetrachloride as the solvent, properly refined oil asphalts are 99 percent soluble. Natural asphalts are somewhat less than in carbon disulfide. Carbon tetrachloride solubility decreases for improperly made or cracked asphalts. Low solubility results from overheating the material beyond its normal thermal stability temperature. Lowered carbon disulfide soluble material may show no lower with carbon tetrachloride. The solubility in these solvents is often specified so that the carbon tetrachloride value is at least 99 percent of the carbon disulfide solubility.

The material insoluble in tetrachloride but soluble in carbon disulfide are "carbenes"—a high carbon content hydrocarbon resulting from further dehydrogenation reactions (cracking) of the asphaltenes. One of the distinguishing characteristics of cracked asphalts, as formerly made, was its carbene content.

86 F. Pennsylvania Paraffinic Naphtha Insolubility shows the degree of oxidation of an asphalt. The insoluble matter increases with decrease in penetration, and is relatively high for asphalts from very high asphaltic base (high asphaltene content) crudes. (See Table 1.)

This test is valuable in following blowing or oxidizing operations and in research. Blown asphalts show lower solubilities for equal penetrations than straight reduced paving asphalts. Insoluble matter increases as longer blowing time causes a decrease in penetration.

TABLE 1
86 F Pennsylvania Paraffinic Naphtha Solubility for Various Vacuum Asphalts

Asphalt Base	Penetration	Percent Solubility
Kuwait	95	88.9
Lagunillas	90	81
Boscan	90–100	78.2
Heavy Gulf Coastal	50	90–100
Panuco (Mexican)	50	70–80

Asphalts containing only the oil and the resin groups have no naphtha insoluable matter due to total absence of asphaltene material. Between polar and nonpolar solvents a long list can be prepared and their solubility effects toward asphalts determined. The solvent power of the solvent for asphalts increases with the surface tension of the solvent.

Ash Tests indicate purity of the material and is used in conjunction with the carbon disulfide test. A small amount of inert ashy matter (0.1 percent or less) is tolerable. Oil asphalts, carefully manufactured from desalted and water free crudes, have practically no ash. Blown or oxidized asphalts are also ash free. Ash may be high in cases where corrosive crudes are reduced, the impurities of the ash coming from corrosion of the equipment.

The natural asphalts are identified by their high ash content compared to petroleum asphalts, e.g., Trinidad—34-36 percent ash; Bermudez Lake (Venezuelan)—7-8 percent.

Oliensis or Spot Test indicates the homogeneity of the asphalt, if it is absolutely free of insoluble carbenes, ashy matter, etc. Originally the test was to distinguish cracked asphalts from well refined reduced asphalts. A small weighed sample of asphalt is dissolved in "Oliensis" naphtha and allowed to stand for 24 hours. A drop of the solution is placed on a standard filter paper.

Upon drying a uniform black ring indicates a negative spot test. A black spot surrounded by a lighter brown colored ring is a positive test.

Some asphalts carefully vacuum reduced without cracking may show a positive test. In this case as much as 35 percent xylene is added to the naphtha or heptane used in making spot test. This modified solvent will still show the presence of cracked asphalts by giving a positive test.

Although the test is controversial it does indicate some heterogeneous characteristics of the material. An overbalance of asphaltenes relative to resin content may produce a positive spot asphalt. Heterogeneity due to this unbalance could exist in the material before adding any solvent, however.

Part 7 will appear in an early issue.

| ABC Pump Co. | | Quantity Required Per Unit | | |

Centralize Your Spare Parts Program . . .

SPARE PARTS RECORD

Page P-17

Unit 732 Still Refinery Houston

Location MS-1&2

Equipment Pump - Centrifugal Equipment No. HT-392295.2

Mfgr. ABC Pumps, Inc. Serial No. 234126

Pur. From Above P. V. No.

Auth. No. HT-11985 Date 1953 Item No. P-21

Reqn. S-1013 Date 4-3-53 Price Not available

Order No. 47207 Date 4-10-53 Freight Not available

Prime or Aux. Equip. Prime Aux. to (or driver) HT-123415.2

Date Received 10-10-53

Name Plate Data:

Service - Depropanizer Reflux Pump

Size	- 3 x 6
Type	- HOBS
RPM	- 3550
GPM	- 400
TDH	- 63
Rotation	- CCW viewed from coupling
Bearings	- MRC 5306 Double Row - Both Ends
Packing	- J. C. Duck Superseal #3
Couplings	- #2 Slow
Impeller Dia.	- 9¼"

Driven by 15 HP ABC Turbine Inc. Turbine, Serial No. 18530, See Page T-7

We have Inspection Report
We have cuts and parts list

FIGURE 2—Catalog face sheets on each item in the unit, are arranged alphabetically.

full advantage can be taken of the interchangeability of parts for equipment manufactured by a given company even though such equipment may be located in different refinery units. The centralized spare parts control group should control the ordering of all repair parts for the entire plant. Using this system, there will be no duplication in the ordering of parts and yet there will be a sufficient supply of parts, needed for any repair, on hand and available for immediate use at any given time.

This plant-wide practice immeasureably reduces the total number of parts the company needs to keep on hand and results directly in an appreciable savings on money tied up in inventory stock. This provides maximum protection at minimum cost.

Compiling Equipment Data. Before such an operation can be put into effect, the centralized control group must know what equipment has to be protected. The best way to obtain this information, even though it is a long process, is to make a physical inventory of the entire plant, listing and cataloging all pieces of equipment along with the serial number, type, size and all other name plate data. This must be followed by a check of the files for acquisition and receiving reports.

On some equipment the name plates, or other identifying information will be missing. In such cases, reliance must be placed on the machinists records or other available means to obtain the necessary information.

Obtaining Parts List. After the equipment records have been compiled, a complete list of each manufacturing company's equipment should be formulated. By working with the manufacturer's representative, service engineers, or their engineering departments, sectional drawings or cuts, recommended spare parts list and interchangeability lists may be obtained. Most manufacturing companies will supply these at a nominal cost, depending upon age of the equipment.

During periods of new construction, the contractors should be required to include on their purchase orders, requests for a suitable number of parts lists, cuts and drawings. Such information is invaluable to those responsible for the ordering of spare parts. It saves time in obtaining the necessary information, for checking parts needed against existing spare parts inventory, and in ordering parts required that are not carried in stock.

Minimum Quantities. The determination of how many of what parts are needed for continued operation is a critical phase of centralized control. This is the phase where many variables enter the picture. Statistical records, historical records, usage records, manufacturers delivery time required, even the human elements are to be considered in varying degrees when ordering the minimum quantity of repair parts.

The parts used and the parts determined necessary for plant wide protection can best be shown by the use of a chart (See Figure 1). For example; line one is an XYZ 6304-ZNR Thrust Bearing. Following across the sheet we find pump serial number 1414721 requires one, serial number 1414722 also requires one, etc. Thirty bearings of this type are used on these particular pumps. This bearing is also used on other equipment throughout the plant. Studying records it was found that, on the average, five bearings were used every six weeks. Delivery time, after storehouse requisition is placed, varies from 1 to 6 weeks, averaging 3 weeks. Therefore, five bearings are maintained as a minimum stock.

Information Distribution. Sinclair Refining Company decided, in setting up a centralized control system, that the best way to circulate complete information to all concerned would be to list all equipment installed on a major unit in catalog form, using a separate catalog for each unit, and to indicate thereon all spare parts being stocked for its protection.

After compiling the physical inventory and securing all information available on each piece of equipment, the information is consolidated into catalogs. The catalog consists of a face sheet (See Figure 2) for each item of equipment. These are indexed and alphabetically arranged by section and page number for convenience in locating the items desired. The information appearing on these face sheets includes identifying numbers and general descriptive information together with other pertinent data such as bearing and packing information; also, whether or not there are inspection reports, drawings and parts list.

Following each face sheet is an unnumbered page or pages (See Figure 3) showing the minimum inventory of parts, as established by centralized control, and their location in the Storehouse by section and bin number or otherwise. These spare parts sheets also indicate the serial numbers and location of equipment on which they will interchange on other units.

Copies of these catalogs are distributed to the engineering division head, the storehouse, the operating foreman of each unit, area engineers and mechanical maintenance foremen.

The catalog serves as a useful reference guide for the mechanical foreman and unit operators, since they can quickly ascertain whether or not spare parts are carried for a particular piece of equipment being repaired and the physical location of the parts in the storehouse. This is particularly useful when repairs are being made on weekends or at night when the regular storehouse personnel are off duty.

Cooperation Required. The success of the centralized control depends a great deal upon the cooperation of the storekeeper and the storehouse personnel. It is obvious that the initial location of the repair parts must be permanent. If the parts are being continuously relocated, an undue amount of work is involved in making new location changes in the catalog. All parts in the storehouse should be tagged because a great many of these parts are very small and sometimes lose their identity.

3 x 6 HOBS

ABC Pumps, Inc.
Pump - Centrifugal
Serial No. 234126

SPARE PARTS

PARTS LISTED ARE MINIMUM STOCK AND MUST BE REPLACED IMMEDIATELY WHEN WITHDRAWN

		Ref. No.	Location	S Cat. No.	Quan.
Bearings	- MRC 5306 Double Row		18-16	26-1215	8
Bushing	- Stuffing Box, Suction	125	46-15	26-1418	1
Diaphragm	- Discharge	128	46-22	26-1414	2
Element	- Rotating		PR-113	SEC 109	1
Gland	- Stuffing Box	126	46-15	26-853	1
Impeller	- Max. dia.	66-163	32-44	26-2424	4
Ring	- Wearing Discharge, #127	25189	46-22	26-1415	2
Ring	- Wearing Suction, #103	25168	46-22	26-1416	3
Shaft	- Complete with lockwashers, locknuts & keys	65-2	62-64	26-2525	1
Sleeve	- Shaft, Discharge	129	46-15	26-1412	4
Sleeve	- Shaft, Suction	104	46-15	26-1413	4
Sleeve	- Short Shaft	154	46-15	26-1417	4
Spacer	- Shaft Sleeve	22748	32-44	26-2423	2

Above spare parts interchange with Serial No. 153866 - 147 Still and Serial Nos. 150969, and 150970 at 732 Still.

FIGURE 3—This form gives the complete minimum parts inventory for equipment indicated on the face sheet.

The storekeeper must reorder daily any parts drawn from stock if the withdrawal of a given item brings the inventory, on that particular item, below the minimum requirements as established by centralized control.

Where there is a rotating assembly for a pump or turbine or any other assembly that does not need be reordered but rather needs a general overhauling for first class restoration, it is sent to the mechanical department for repair, then returned to the storehouse stock. Records and controls may be kept on these items by the use of a follow-up form (See Figure 4) to be filled out by an authorized person in the mechanical repair department and sent to centralized control.

Follow-Up. A system of this type requires constant checking as equipment is transferred from one unit to another, new equipment is purchased and old equipment is junked. Therefore, centralized control should check the various unit equipment catalogs at stated intervals and when equipment has been removed from the unit, the face sheets and parts pages from that unit's catalog should be removed. Where new equipment has been transferred into a unit, face sheets and parts pages covering that equipment should be incorporated into that unit's catalog.

Many times the changing of the service of a piece of equipment will require the changing of the repair parts needed for this equipment. Therefore, periodically, centralized control has to review the inventory

Date _____

To: Centralized Control

The following was received in the Machine Shop today for repairs (Check one):

- ☐ Rotating Element - Centrifugal Pump
- ☐ Rotating Element - Turbine
- ☐ Liquid End - Pump
- ☐ Mechanical Seal
- ☐ Other (Please List)

_____

_____

_____

This is for _____ Serial No. _____

MT No. _____ Located at _____

This item can be repaired and returned to Storehouse in approximately ___ Days.

This item needs the following parts to repair and put in first class order:

_____

_____

_____

_____

_____

_____

_____

- ☐ The cost of repairing this item will be in excess of purchasing new item.
- ☐ This item cannot be repaired and should be junked.

_____
Machine Shop

FIGURE 4—When parts need overhauling, the machine shop completes this form.

of repair parts and establish new minimums, add new items and delete some items. Whenever this is done, changes in the parts catalog should be noted, and revised parts sheets issued to all concerned.

Economy. There is no one best way to show the dollars and cents savings immediately, but a comparison of repair parts cost for a certain period before a centralized control is installed, versus repair parts cost for a like period after centralized control is functioning smoothly, will show a definite savings.

The investment in spare parts is inversely proportional to the degree of standardization of equipment and considerable improvement could be obtained in this regard by more careful consideration in the initial selection of equipment.

This type of control can be used not only in intra-plant but in inter-plant organizations as well.

Any company that installs such a control system should not expect their repair cost to drop immediately. They will find that they are over protected on some equipment and have no protection on other equipment. The expense of protecting the unprotected equipment will probably offset the savings accomplished on the interchangeability of parts until the designated level of spare parts inventory is obtained.

Example. Following is an example of repair cost that came to light after the Sinclair Refining Company installed the centralized control.

In 1952, this company entered into contracts with two major construction companies to design and construct two new operating units. On these two units there was a total of 71 turbines. Both construction companies purchased the turbines from the same manufacturer.

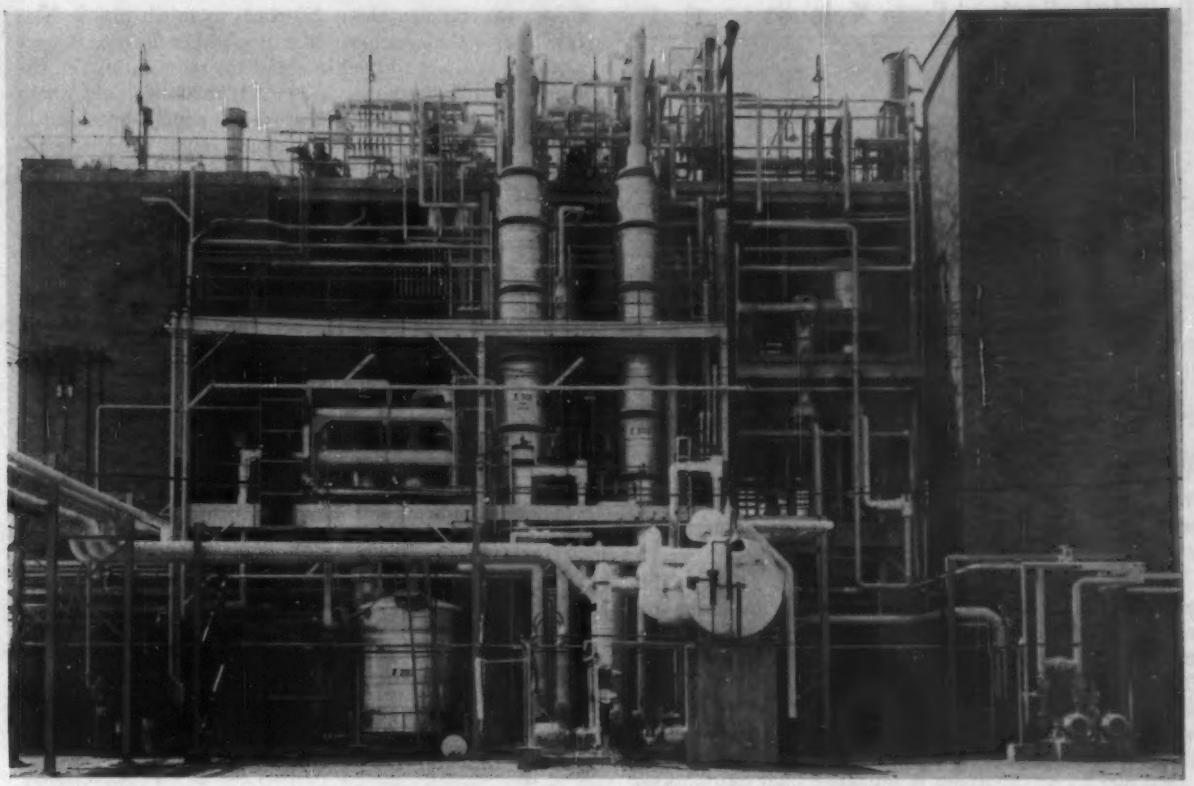
At this time, it was one of the duties of the various operating foremen to see that all spare parts for his individual unit were on hand. Two operating foremen, assigned to these units, compiled their list of spare parts to be maintained on these turbines. The sectional drawings furnished on these turbines did not have parts numbers but did have reference numbers.

Through past experience, the foreman knew that the governor bearing on turbines would need to be replaced. Therefore, they each ordered a governor bearing for each type of turbine, on their unit.

The turbine manufacturer furnished 39 bearings, all identical, at list price. These bearings are standard bearings carried in stock in the local bearing supply houses and the company may purchase them at list plus a substantial discount, with a one-hour delivery, if an emergency arises. After five years operation of the two units, the storehouse still had fifteen of the original bearings in stock. When you consider that there are several thousand spare parts items, it is easy to see that a centralized control system, with time to investigate parts before purchasing, is a profitable system. ##

About the Author

Carl M. Masters, Jr., has been the spare parts centralized control supervisor for Sinclair Refining Co. at the Houston refinery for the past 4 years. He has been affiliated with Sinclair for 15 years in various phases of engineering. Prior to that he spent several years with an oil field equipment manufacturer. Masters received his B. S. degree in industrial engineering from the University of Houston.



Hercules' plant at Burlington, N. J., uses air oxidation of xylenes for the production of dimethyl terephthalate.

Compare these routes for . . .

Terephthalic Acid From Xylenes

Peter W. Sherwood
Chemical Engineer, White Plains, N. Y.

TEREPHTHALIC ACID is one of the important growth petrochemicals of the 1950's. Commercial production, begun in 1951, reached an estimated 25 million pounds in 1953 and is now close to an annual output of 80 million pounds. Outlook for future growth in TPA (terephthalic acid) demand continues good, with 1960 production forecast at the 125 million-pound level.

The big boost to terephthalic acid production was given by the popular acceptance of derived synthetic polyester fibers and films. Still other commercial polyesters employ terephthalic acid esters as one of their raw materials.

Now, the bulk of terephthalic acid is captively produced by DuPont. Oronite's isophthalic acid plant at Richmond, Calif. is designed for ready adaption to terephthalic acid manufacture. Hercules Powder Company operates a dimethyl terephthalate plant at Burlington, N. J. In addition, Standard Oil Company (Indiana) is now building a plant for the production of the three phthalic acids, of which terephthalic acid is the second-most important. Total planned output for this unit is 60 million pounds/year.

Other interested firms which have, however, not gone beyond the pilot-plant scale so far, include Shell Chemical Company and Richfield Oil Company.

All present production of terephthalic acids and its esters is obtained by the partial oxidation of p-xylene. Where TPA alone is the desired product, this hydrocarbon must be provided in 95-98 percent concentration, with recent demand inclined toward the higher purity.

There are today five producers of specification-grade p-xylene in the United States. All employ a C_8-fraction of petroleum reformate as feedstock. A typical starting mixture will contain 8-20 percent ethyl benzene, 15-20 percent p-xylene, 40-55 percent m-xylene, with o-xylene making up most of the remainder.

These components have the following boiling points at atmospheric pressure:

Ethyl benzene	136.2 C.
p-xylene	138.5 C.
m-xylene	139.2 C.
o-xylene	148.8 C.

A look at this table shows at once that o-xylene may be removed from the mixture as bottoms in a fairly simple distillation step. This step can be clearly justified if o-xylene can be valued as feed for phthalic anhydride manufacture. Otherwise, the profitability of undercutting is marginal.

Less straight-forward is the removal of ethyl benzene. The boiling point spread from its closest neighbor is only 2.3 C. Only one installation is known (namely Cosden's Big Spring, Texas plant) where ethyl benzene is removed from p-xylene by fractionation—and here, the chief purpose is to recover ethyl benzene as raw material for styrene production.

Where the object is the purification of p-xylene, a different situation exists. Distillative methods are unfeasible in any event for the separation of p-xylene from m-xylene, and resort must be had to crystallization. Under these circumstances, one cannot justify the cost of distillative removal of the relatively small amount of ethyl benzene which is continued in the feedstock, and p-xylene is isolated from its mixture with ethyl benzene and m-xylene by crystallization processes which we shall describe later.

As one might expect, this method of purification is quite costly. Cash operating costs in a p-xylene crystallization process have been estimated at 2-3 cents per pound of product. Including the net cost of feedstock and allowing a three-year payout on investment, p-xylene becomes a 14-17 cent per pound hydrocarbon.

It is no wonder, therefore, that intensive efforts have been made to find alternative feedstocks for terephthalic acid production. In the manufacture of phthalic esters, it is possible to feed a mixture of p- and m-xylenes which are jointly oxidized and esterified. The product esters can be separated by fractional distillation. This is reported to be the course chosen by Hercules which produces dimethyl terephthalate as well as dimethyl isophthalate at its 12 million pounds per year installation at Burlington, N. J.

Other approaches have been explored for the use of mixed xylenes as raw materials in terephthalic acid production. One such method would esterify the oxidation product selectively, taking advantage of the fact that isophthalic acid can be converted to its dimethyl ester without catalyst, while terephthalic esterification calls for the presence of a strong mineral acid. Another approach calls for oxidation in two stages with separation of the isomeric toluic acids which are formed as intermediates.

But to date none of these processes has provided an economic means for the production of terephthalic acid as such. *(Publicity has recently been given to one process which reportedly permits economic production of TPA from mixed xylenes, but no details on the separation step have become available.)* This is partly due to product degradation in recovery. Certainly an important obstacle is also the unbalance of the product. Since petroleum reformate contains about 2.5 times as much m-xylene as p-xylene, we may expect that isophthalic acid and terephthalic acid are formed in about the same ratio. Yet, the market for isophthalic acid is, at present, only about two-thirds of that for TPA, certainly not in a position to absorb large amounts of IPA which might become available as by-product.

These are the considerations which have so far kept mixed xylenes from playing an important part in the production of terephthalic acids and have compelled costly purification of the para-isomer.

High cost is, however, only one of the drawbacks of p-xylenes as raw material. Unlike o-xylene, which can be readily oxidized to phthalic anhydride by vapor-phase reaction with air, the oxidation of p-xylene to TPA is attended by difficulties. One-half of the conversion—to toluic acid—is simple enough, but oxidation of the second methyl group calls for special techniques which are discussed below.

These technical and economic difficulties have been responsible for intensive research into the production of terephthalic acid from raw materials other than p-xylene. Among these, toluene is probably the most attractive. At least three processes for its use as starting material in TPA synthesis have reached pilot plant development stage.

Other raw materials mentioned—but not currently employed—for TPA synthesis, include di-isopropyl benzene and p-cymene. The former is reportedly oxidized with greater ease than p-xylene, using a process which has been piloted by Shell in Holland. p-cymene (= para-iso-propyl toluene) is available as by-product of cellulose production from coniferous woods. Finally, it is possible to synthesize p-xylene with almost no formation of the meta-isomer, by dimerization of butadiene.

It would lead us too far afield to consider the use of all of these raw materials. At this writing, p-xylene alone serves as starting material in the large-scale production of TPA. The remainder of this article will therefore be concerned with commercial and semi-commercial techniques which serve for the isolation and oxidation of p-xylene.

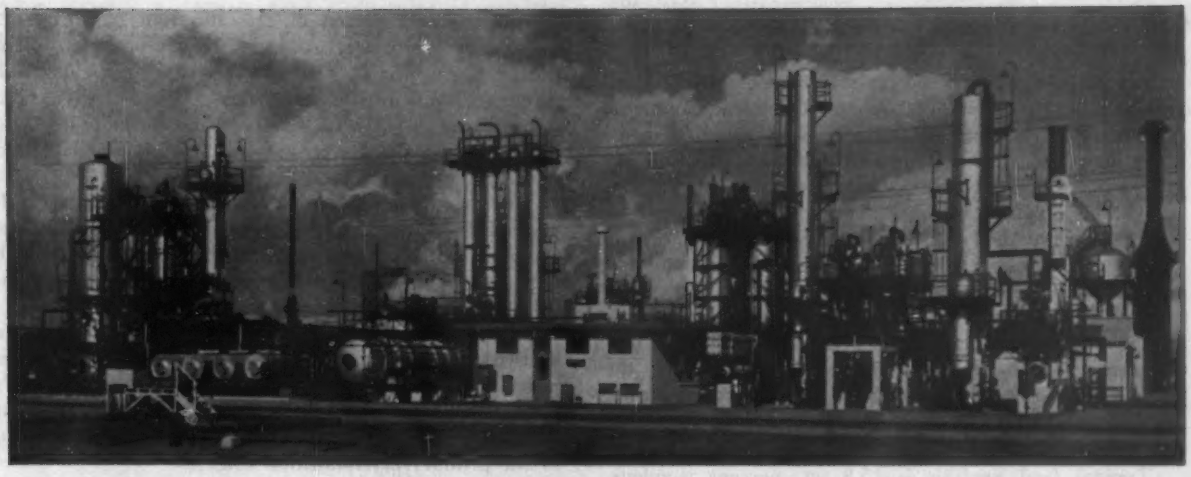
Purification of p-xylene. Five refiners are today engaged in the commercial recovery of p-xylene. Estimates of 1955 capacities at four of these plants have become available[1] and are as follows:

Producer	1955 Plant Capacity (mm lbs./year)
Standard Oil (California)	40
Humble	25
Sinclair	10
Phillips	5

Capacity of Cosden's p-xylene unit has not become known.

In the interim, additional capacity estimated at 15-20 million pounds has been installed. Total output of refined p-xylene is estimated at 72 million pounds in 1955,[2] 80-85 million pound in 1957. An expansion project, now underway, will add 25 million pounds/year to Standard Oil Company (California's) capacity by early 1958.

At all of these installations, p-xylene is purified by crystallization. Advantage is thereby taken of the fairly wide spread in freezing points, which is 13.3 C. for p-xylene, —25.2 C. for o-xylene, —47.9 C. for m-xylene and —95 C. for ethyl benzene.



Oronite's isophthalic acid plant uses sulfur as the oxidizing agent, is very flexible in design, and can be converted to terephthalic acid production.

The amount of para-xylene which can be recovered by crystallization depends on the composition of the feedstock and on the required purity of product. The binary system meta-, para-xylene forms a eutectic mixture which contains 87 parts of the meta-isomer and 13 parts of the para-compound. Its freezing point is —54 C. Pure p-xylene can therefore be crystallized from the binary mixture only as long as its para-content exceeds 13 percent.

Separation of p-xylene from o-xylene by crystallization is even more limited. In the binary mixture of these components, the eutectic occurs at a p-xylene concentration of approximately 25 percent.

The extent of para-xylene recovery can be raised by the presence of various low-melting solvents in the system. McArdle and Mason[3] propose the use of a light solvent such as pentane. Starting with a mixture of 71 percent meta-, 21 percent para-, and 8 percent other C_8-aromatics, McArdle adds an equal volume of n-pentane. When this mixture is cooled to —70 C., approximately 70 percent of the initial p-xylene will crystallize in high purity. If isopentane is chosen as solvent, recovery of para-xylene can be boosted to as much as 91 percent by crystallization at —85 C.

For purposes of economic comparison, it must be borne in mind that high yield of p-xylene from a given feedstock is important only insofar as it reduces costs of the crystallization operation. It means nothing in terms of raw materials cost for the effluent C_8-mixture has the same unit value as the feedstock, without regard to its p-xylene content.

Thus, despite its favorable effect on yield, the use of solvents has major economic drawbacks in that it calls for operation at very low temperature and necessitates refrigeration of very much larger quantities of material than is the case in recovery of p-xylene from an undiluted mixture of C_8-aromatics.

An attractive approach to the separation of para-xylene from C_8-reformate calls for co-crystallization with carbon tetrachloride. This chemical forms an additional compound with para-xylene which can be crystallized, providing a very high yield of the desired xylene isomer. This technique has been developed by California Research Corporation.[4]

Starting with a mixture of 18 percent p-xylene and 82 percent m-xylene, pure crystallization by cooling alone will permit para-xylene recovery only to the eutectic point, at which stage the mother liquor still contains 13 percent of the desired product. If, on the other hand, 54 mole percent CCl_4 is added to the starting mixture, the compound of p-xylene and carbon tetrachloride will begin to crystallize at about —40 C. Maximum exploitation is attained by cooling to —77 C. At this point, m-xylene will just begin to co-precipitate. The mother liquor contains only one percent para-xylene which is equivalent to about two percent on a CCl_4-free basis.

At this temperature, then, recovery of p-xylene is somewhat better than 90 percent.

Separation of carbon tetrachloride from p-xylene is easily effected by straight distillation.

In the processing of a C_8-reformate fraction by straight crystallization, the presence of ethyl benzene exerts a solvent effect—i.e., it will permit higher yield of p-xylene but will also necessitate crystallization at lower temperature. Meta-xylene exerts the same effect on the system para-, ortho-xylene.

Serious thought must be given to the question whether o-xylene should be fed to the crystallizers at all or should be previously removed as bottoms in a fractionation step. Because its melting point is closest to that of p-xylene, the ortho isomer imposes the lowest limit on yield, in its absence p-xylene recovery can be increased by a moderate decrease in temperature. Furthermore, the removal of o-xylene from the system decreases the stream volume which must be refrigerated.

The question whether these benefits warrant the cost of undercutting for ortho-xylene removal, depends on two chief factors:

1. o-Xylene content in the plant feed, and
2. The marketability of by-product o-xylene.

With o-xylene content of most C_8-aromatic petroleum fractions within fairly close limits, the second factor becomes determining.

Standard Oil Company (California), which has an

outlet for o-xylene in the manufacture of phthalic anhydride by its subsidiary, Oronite Chemical Company, removes this isomer from the C_8-feed mixture to its p-xylene crystallization unit. Humble Oil & Refinery Co., on the other hand, does not practice the prior removal of o-xylene since it does not have so ready a market for this hydrocarbon. In the latter instance, the unit value of o-xylene is therefore no higher than that of the unseparated xylenes mixture.

Operating data for Humble Oil & Refining Company's p-xylene recovery plant have been reported.[2] This unit employs a two-stage crystallization technique. In the first step, p-xylene is recovered in 80 percent purity. Further upgrading to 95-98 percent is effected by melting and recrystallization of the 80 percent crystals.

Typical feed analysis is 15.8 wt. percent p-xylene, 39.6 percent m-xylene, 20.0 percent o-xylene, 18.6 percent ethyl benzene, 3.5 percent toluene and 2.5 percent others. Co-crystallization of o-xylene from this mixture will begin at —72 C. which is therefore the limiting temperature. p-Xylene solubility at this point is 5.4 percent. Yield of p-xylene from the above feed mixture cannot therefore exceed 10.1 percent, based on a total mixture, or about 64 percent of p-xylene initially present.

In Humble's process, the feed mixture is dried by passage through a bed of activated alumina. The hydrocarbon stream is pre-cooled to —37 C. and is then fed to the inner tube of a double-walled heat exchanger where it is cooled further by ethylene refrigeration. The liquor passes to an agitated hold-up tank and from there to a second ethylene-cooled scraped-well heat exchanger in which the temperature is lowered to —70 C. Effluent from this final cooling stage is taken to a hold-up tank in which crystal formation at —70 C. is allowed to proceed to completion. The two-step cooling and crystallization technique is employed to permit formation of crystals which are large enough to be filtered.

The resulting slurry is fed to semicontinuous centrifugals where p-xylene crystals of 80 percent purity are separated. These crystals are taken to a heated tank in which they are melted at 24 C. They are then charged to the second crystallization stage.

Here, the liquor is pre-cooled to 7 C. It is then charged to another wall-scraped heat exchanger in which it is cooled to —18 C. At this temperature, p-xylene crystals of high purity form readily in a filterable size. The final crystallization is allowed to proceed to completion in a hold-up tank at —18 C. and the resulting slurry is filtered in semi-continuous centrifuges.

The mother liquor contains some 42 percent p-xylene and is recycled to the first crystallization stage. The product crystals assay 95 percent at the conditions described, but higher product purity (approximately 98 percent) can be attained by adjusting conditions in the second crystallization stage of the process.

A somewhat different approach to p-xylene purification is taken by Standard Oil Co. of California. Here, internal refrigerant is used in the crystallization stages. This makes the use of wall-scraped heat exchangers unnecessary but requires separation of the internal refrigerant from the mother liquor.

Still another method of crystallization has been developed by Phillips for use in its p-xylene recovery plant at Big Spring, Texas. Here, a first-stage crystallization is carried out in scraped-surface chillers with a final temperature of —77 C. The resulting slurry is taken to a rotary filter on which p-xylene crystals are separated in 65 percent purity.

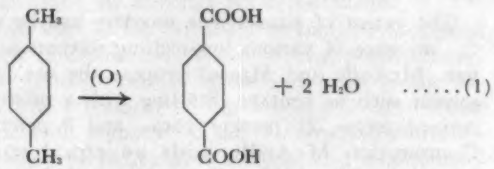
The crystals are melted and re-crystallized in secondary chillers with an outlet temperature of —18 C. The slurry is fed to a continuous purification column which is a rather unique piece of equipment, intended specifically for the production of high-purity p-xylene.

This column has a piston at the top and filter media in two sections of its wall. A horizontal, flat heater is provided at the bottom. The slurry is fed to the column's side. Pressure exerted by the piston forces liquid out through the filter walls (this mother liquor is recycled to the primary crystallization stage).

Crystals are retained in the column, and replenished from the top by the piston's repeat action. The heater in the column's bottom melts the bottom layer of crystals. The resulting liquor is partly withdrawn as product. The remainder is forced upward through the crystal bed, thereby exercising a purifying reflux action. The reflux liquor is eventually withdrawn through the column's filter walls.

This method of operation is stated to produce p-xylene of 98.5 percent purity continuously, and as a matter of routine. Purity in excess of 99 percent can be obtained if needed.

Oxidation of p-xylene. Over-all the synthesis of TPA from p-xylene is carried out in accordance with Equation (1):



.....(1)

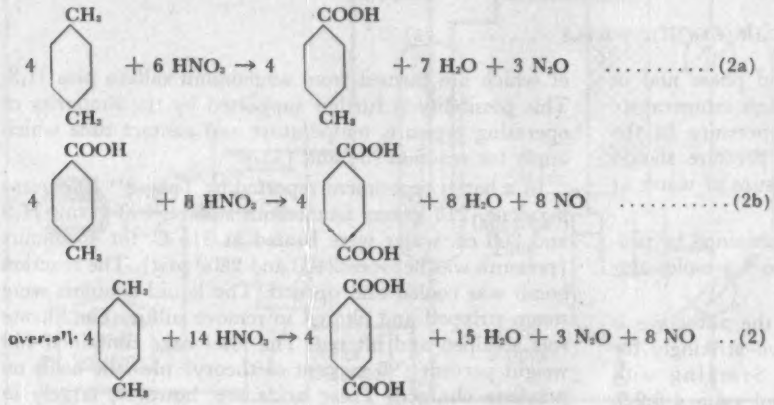
The lowest-cost oxidizing agent is, of course, air. Several processes are at hand to bring about this conversion. However, while it is a relatively simple matter to oxidize one of the two methyl groups (to yield p-toluic acid), oxidation of the second methyl group to form TPA in good yield is quite difficult. Cost of oxidizing agent must therefore be weighed against yield on p-xylene and other considerations.

An air oxidation method is being employed by Hercules, and another such process is intended for use at Standard Oil Company's (Indiana) plant, now under construction at Joliet, Ill. A process has been taken through the pilot-plant stage by Richfield Oil Co., in which air serves only for the first conversion stage (i.e., to toluic acid).

DuPont, at present the largest producer of terephthalic acid, oxidizes p-xylene by nitric acid. Oronite's xylene oxidation plant employs sulfur as an oxidizing agent.

Just what is involved in the technical execution of these commercial and near-commercial processes for the oxidation of p-xylene will be the subject of the following discussion.

1. Oxidation by Nitric Acid. Conversion of p-xylene to TPA takes place in two steps. The following (approximate) equations appear to apply for each stage:



Operation at moderate temperature (below 130 C.), will form predominantly p-toluic acid, accompanied by only minor amounts of terephthalic acid.

In 1953, two publications[6,7] announced the feasibility of guiding reaction (2) to the formation of TPA in high yield, by operating at temperatures above 150 C., and preferably about 200 C.

In exploratory experiments, Bengtsson[6] mixed 25 percent HNO_3 with an equimolar amount of p-xylene and obtained a TPA yield of 86 percent (presumably on xylene converted) at 165 C. He found further that operation with excess nitric acid and above 200 C. led to more extensive oxidation.

Burrows[7] finds that there is a threshold temperature range of 130-150 C., below which rate of TPA formation is negligible. Between 150 annd 180 C., terephthalic acid formation proceeds with fair rapidity but the product is contaminated by the presence of some 10 percent p-toluic acid. Best conversion and product purity is obtained between 200 and 230 C. In this range, yield of TPA as high as 89 percent (on xylene charged) can be obtained in high purity since p-toluic acid content of product is less than 1 percent. Temperature should not exceed 230 C., because TPA degradation becomes quite rapid above this level.

Nitric acid strength is not very critical; the preferred range is between 25 and 40 percent. Ratio of nitric acid to xylene, on the other hand is important. Burrows states a preferred ratio of 2.4 pounds 100 percent HNO_3 per pound xylene, and reports yield of 89 percent at a reactants' ratio of 2.1. This points to remarkably high utilization of nitric acid when it is borne in mind that theoretical requirements of equation (2) are 2.1 pounds HNO_3 per pound xylene.

The process must necessarily be carried out at elevated pressure so that liquid-phase conditions will be maintained. Controlling is the vapor pressure of water in the system. If this pressure is exceeded substantially due to accumulation of by-product gases (NO and N_2O) in the vapor space, the extent of side reaction will increase, and an explosion hazard is created. Typically, total pressure of the system will be about 400 psig for operation above 200 C.

The reaction is carried out in an agitated autoclave provided with cooling coils. To hold the pressure within allowable limits, evolved gas (chiefly NO and N_2O) is taken off overhead via a reflux condenser and through a back-pressure valve. Following completion of the reaction, the product is withdrawn from the reactor, cooled, and filtered for the recovery of terephthalic acid which is insoluble in the aqueous medium.

In a typical run, p-xylene was reacted with 31 percent nitric acid at 221 C. Net nitric acid: hydrocarbon ratio was 2.1. Reaction time was 59 minutes. Crude terephthalic acid was formed in 89 percent yield, and contained 99 percent dicarboxylic acids.

A particularly interesting aspect of this process is Burrows' finding that the yield from the oxidation of p-xylene to p-toluic acid amounts to as much as 89 percent, while the yield from the oxidation of p-toluic acid to TPA may be as high as 98 percent—i.e., the first step is yield-controlling.

This finding is in line with several developmental processes which carry out p-xylene conversion in two stages: Air oxidation to p-toluic acid followed by nitric acid oxidation of the second methyl group. Such an approach is reportedly the basis of Richfield Oil's pilot plant process. A similar approach in Europe is claimed to have led to 95 percent TPA yield.

The attraction of a two-step process is evident. It provides a basis for producing TPA in high yield, at the same time that it reduces nitric acid consumption by nearly 40 percent below that in single-stage HNO_3 oxidation.

2. Oxidation by Sulfur Compounds. An alternate approach to xylene oxidation which is useful for the production of both terephthalic and isophthalic acid, employs sulfur or sulfates as oxidizing agent. Aqueous ammonia is the reaction medium. A number of reports[8,9,10] suggest that this approach is employed commercially by Oronite Chemical Co. for the oxidation of m-xylene to isophthalic acid. Oronite's plant is designed to permit ready adaptation to terephthalic acid production.

Patent coverage by California Research Corp. outlines two courses for this type of reaction:

(a) Oxidation by elemental sulfur in the presence of ammonia and water, and

(b) Oxidation by aqueous ammonium sulfate in the presence of sulfides.

The chemistry of the two methods is interrelated.

Using Elemental Sulfur. Xylene is reacted with sulfur, and a large excess of water, in the presence of am-

monia, to yield terephthalic acid and ammonium sulfide:

$$p\text{—}C_8H_{10} + 6\,S + 4\,H_2O \xrightarrow{(NH_3)} p\text{——}C_6H_4(COOH)_2 + 6\,H_2S \quad \text{.....(3)}$$

The reaction is carried out in the liquid phase and in the absence of a catalyst. It calls for high temperature (315-360 C.), and correspondingly, a pressure in the range of 2500-6000 psig. Total system pressure should be at least 400 psi above the vapor pressure of water at operating temperature.

Aroyan[11] states that best efficiency is obtained by providing 6 to 9 gram-atoms sulfur and 2 to 4 g-moles ammonia per g-mole p-xylene.

The ratio of water to xylene fed to the autoclave is particularly critical. This effect is shown strikingly for the sulfur oxidation of m-xylene.[12] Starting with m-xylene, sulfur, and ammonia in a mol ratio 1:6:2.5, and operating at 315 C., the following conversions to phthalic acids were obtained after 10 minutes, 15 minutes, and upon completion of reaction (regardless of duration):

Feed Mol Ratio, Water:xylene	10-Minute Conversion, Mole Percent	15-Minute Conversion, Mole Percent	Maximum Conversion to Phthalic Acids, Percent
100	70	80	93.1
25	39	52	91.8
10	5	8	69.5

Parallel results, with slightly better conversions, are obtained in the conversion of p-xylene to TPA. A further advantage of high water: xylene ratio is the fact that it leads to product of better quality.

This process can be operated in a continuous, tubular reactor. Here, a critical relation is claimed[11] between yield and the product of tube diameter times mass velocity of the reaction mixture which should be at least $10{,}000\frac{\text{lbs.}}{\text{ft.-hr.}}$ for reactor tubes from 2 to 12 inch diameter. Residence time is between 15 and 45 minutes.

Following completion of the reaction, the product is cooled and depressured. A steam stripping step serves to remove ammonia and lower pH to 6-7. The liquor is then filtered for sulfur removal, saponified with NaOH for decomposition of phthalic acid amides and ammonium salts, and is once again steam-stripped. It is then sprung to a pH of 6-7 by H_2SO_4 and is decolorized with active charcoal. Finally, phthalic acids are precipitated by acidification to pH 2. This product is filtered off and washed with water.

According to Toland,[13] the first steam-stripping step and sulfur filtration can be eliminated by releasing the system to the vapor pressure of water, while it is still at reaction temperature.

Using Ammonium Sulfate. A related approach to the oxidation of p-xylene calls for the use of aqueous sulfate plus sulfide as oxidizing medium. The following over-all reaction applies

$$C_6H_4(CH_3)_2 + 1.5\,(NH_4)_2SO_4 \rightarrow 1.5\,H_2S + H_2O + NH_3 + \left\{ \begin{array}{c} C_6H_4(COONH_4)_2 \\ \text{also } (CONH_2) - C_6H_4 - (COONH_4) \\ \text{also } C_6H_4(CONH_2)_2 \end{array} \right\} \quad \text{.....(4)}$$

The fact that this reaction must be initiated by sulfides suggests that the effective oxidizing agent here, too, is elemental sulfur, or at least ammonium polysulfide, both of which are formed from ammonium sulfate plus H_2S. This possibility is further supported by the similarity of operating pressure, temperature and contact time which apply for reaction (3) and (4).

In a batch experiment reported by Toland[14] 106 grams p-xylene, 218 grams ammonium sulfate, 200 grams H_2S and 800 cc. water were heated at 315 C. for 1½ hours (pressure was between 2400 and 2800 psig). The reaction bomb was cooled and opened. The liquid contents were steam-stripped and filtered to remove sulfur. The filtrate was acidified and filtered. The filter cake contained 149 weight percent (95 percent of theory) phthalic acids on p-xylene charged. These acids are, however, largely in the form of ammonium salts and amides.

Conversion to commercial TPA calls for decolorization by carbon and hydrolysis in the presence of sulfuric acid. Aroyan[15] reports very substantial losses of phthalic acid values during these last two steps but finds that these losses can be largely prevented by digesting the primary reaction product, together with additional water, at 245-275 C. for about 12-15 minutes before the liquor is taken to the decolorizer.

Figure 1 shows a flow sheet of this version of the process.

3. Oxidation by air, for obvious reasons of raw materials cost, has probably had the greatest amount of effort directed toward its use as an oxidizing agent for p-xylene.

Unlike the present commercial oxidation of o-xylene, the air oxidation of para-xylene calls for operation in the liquid phase. Almost universally, a soluble cobalt or manganese salt serves as catalyst, but various promoters may be provided with it. Among other proposed catalysts, we might mention SeO_2, NaOH, and A_2OH. Reported yields with these last named catalysts is quite low.

In an early process due to Bowden,[16] .002-.02 weight percent cobalt oleate or naphthenate is dissolved in p-xylene. The solution is fed continuously to an agitated reaction vessel into which air is also introduced. Reaction is carried out at 130-145 C.; the off-gas is scrubbed by p-xylene reflux in a packed, overhead dephlegmator.

Since most of the intermediate oxidation products are oil-soluble, while TPA is insoluble, it is feasible to remove a side stream from the reactor continuously, filter it, and return the mother liquor to the reactor. Incoming xylene is used to wash the filter cake. Yield is reported to be 90 pounds solids for every 100 pounds of xylene consumed. The crude product assays about 77 percent TPA.

This performance is far short of the demand which must be imposed on a commercial oxidation process, in regard to both product yield and purity. It is today recognized that air oxidation proceeds in steps—conversion to p-toluic acid, which proceeds readily and final oxidation to terephthalic acid.

We have noted above, that different oxidation meth-

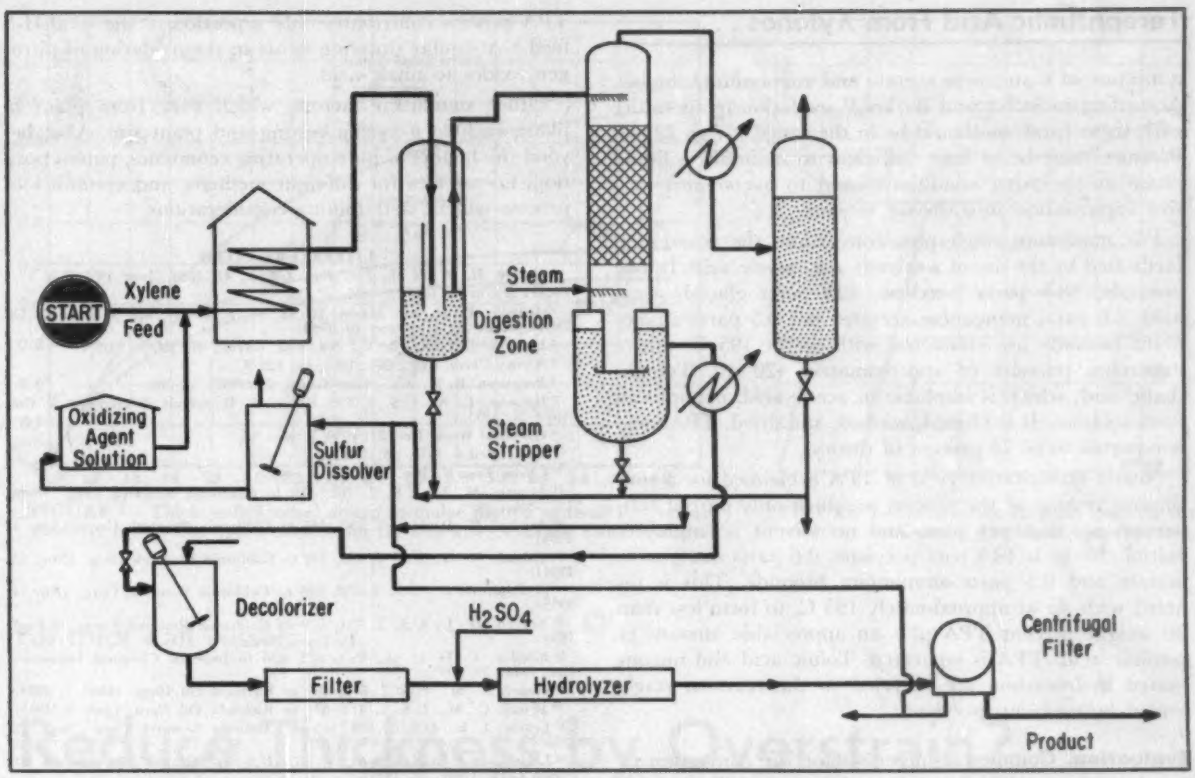


FIGURE 1—Phthalic acid preparation by oxidation of xylene with aqueous ammonium sulfate.

ods may serve for the two stages: air oxidation of p-xylene to toluic acid followed by nitric acid oxidation to TPA. The latter step has already been discussed, and we must now consider the first part of such a combination process.

In a toluic acid process developed by Richfield Oil Corp.[17,18] xylenes containing 0.5 weight percent cobalt toluate are contacted with air at 200 psig and 140-155 C. in a cooled reactor. Conversion per pass is limited to 20-40 percent. At the reaction conditions, the bulk of by-product water is carried off overhead with spent air.

A stream of reaction liquor is withdrawn continuously from the converter and is cooled (by flash vaporization) to 40-75 C. in the presence of gaseous oxygen (in order to maintain the catalyst in soluble form). At this temperature, the product is filtered for the removal of precipitated toluic acid plus some terephthalic acid. The filtrate, together with xylene taken off in the flash vaporization, is recycled to the oxidizer. Yield is not clearly reported; it appears to be between 92 and 96 percent of theory.

Air oxidation of toluic acid to terephthalic acid is facilitated if the carboxyl group is tied up by esterification or by formation of toluic anhydride. The former approach underlies the manufacture of dimethyl terephthalate by Hercules Powder Co.

Methyl toluate is prepared by refluxing toluic acid with more than stoichiometric equivalent of methanol in the presence of HCl. The ester is then contacted with air at 190 to 217 C. and elevated pressure (up to 200 psig) in the presence of cobalt toluate. In one run in which .005 weight percent catalyst was employed at 214 C., yield after 4¾ hours is reported at 70 percent of theory.[19] Reaction time can be reduced by recycling about 2 weight percent of crude product which acts as initiator.

Where the diester is the desired product, the crude oxidation product is reacted with an excess of methanol at 149 C. in the presence of a strong acid (e.g., 0.5 weight percent paratoluene sulfonic acid). The resulting dimethyl phthalates may be separated from each other and from methyl toluate by vacuum distillation.

Improved yield for the over-all formation of aromatic carboxylic acids is claimed[20] for the air oxidation of a mixture of xylene and methyl toluate in the presence of an oil-soluble cobalt salt and at about 192 C. The useful product is a mixture of the phthalic acid, toluic acid, and methyl acid phthalate which correspond to the feed isomer.

Interest has been aroused by an air oxidation process recently purchased by Standard Oil Company (Indiana) from Scientific Design Company. It has been announced that this method will be employed at Indiana's plant now under construction at Joliet, Ill.

This process version is also carried out in the liquid phase and is stated to be suitable for oxidation of all three xylenes (liquid-phase processes described above are generally applicable to all three xylenes, but fall short of commercial yield requirements for the production of phthalic anhydride from o-xylene, which rests today entirely on vapor-phase oxidation).

Most likely choice of catalyst in Indiana's process is

a mixture of manganese acetate and ammonium bromide. According to Saffer and Barker,[21] oxidation temperature with these catalysts should be in the range 170 to 225 C. Pressure must be at least sufficient to maintain a liquid phase at operating conditions—and to overcome excessive vaporization into the air stream.

For maximum single-pass conversion, the reaction is facilitated by the use of a solvent, e.g., acetic acid. In one example, 48.8 parts p-xylene, 125 parts glacial acetic acid, 0.6 parts manganese acetate, and 0.5 parts ammonium bromide are contacted with air at 195 C. and a maximum pressure of approximately 420 psi. Terephthalic acid, which is insoluble in acetic acid, precipitates from solution. It is filtered, washed, and dried. TPA yield is reported to be 75 percent of theory.

Nearly quantitative yield of TPA is claimed for a continuous version of the process in which only partial conversion is taken per pass, and no solvent is employed. Initial charge is 48.8 part p-xylene, 0.6 parts manganese acetate and 0.5 parts ammonium bromide. This is reacted with air at approximately 195 C. to form less than 20 weight percent TPA plus an appreciable amount of p-toluic acid. TPA is separated. Toluic acid and unconverted hydrocarbon are recycled to the reaction stage, joined by make-up p-xylene.

Evaluation. Commercial processes for the conversion of p-xylene to terephthalic acid employ three different oxidizing agents—air, sulfur, and nitric acid.

In the last analysis, air serves as oxidizing medium for all three approaches. Oxidation by sulfur yields—upon reaction with water—hydrogen sulfide as by-product. In an auxiliary installation, H_2S may be readily reconverted to sulfur by partial combustion with air. Processes for this auxiliary conversion are well established and are today a routine operation in refinery practice. If sulfur is fed as H_2SO_4, as provided in an alternative process version described above, by-product H_2S may be oxidized to H_2SO_4 either directly or via elemental sulfur.

Similarly, the use of HNO_3 in the oxidation of p-xylene, yields NO and N_2O as gaseous by-products. Reaction with air in an auxiliary installation will readily convert these nitrogen oxides to N_2O_5, the anhydride of nitric acid.

Evidently, such auxiliary processing calls for additional investment and operating cost. At first blush, the direct oxidation by air would therefore seem particularly attractive. However, we must not overlook the cost of air compression, nor the need for solvent recovery and reconcentration in cases where a solvent such as acetic acid is employed.

In an evaluation of the various available processes, the yield of TPA is a weighty consideration. E.g., it does not take much improvement in yield on p-xylene to pay out a sulfur recovery plant in short order, or to pay the price of H_2SO_4 as make-up to the oxidizing mixture. Account must also be taken of the manufacturer's operating position. Conversion of H_2S to sulfur or sulfuric acid is a very low-cost operation if it may be calculated on a pro-rated or on an incremental basis (i.e., if the TPA process contributes only a portion of the total H_2S feed.) A similar situation exists in the oxidation of nitrogen oxides to nitric acid.

Other significant factors, which vary from plant to plant, include p-xylene costing and plant size. Also, beyond the factors o. pure operating economics, patent position, license fees for different methods, and versatility of process will be determining considerations.

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About the Author

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Sherwood received his undergraduate training and his M.S. degree in chemical engineering from Columbia University. In October, 1945, he was invited to join the Technical Oil Mission to Germany where he spent more than a year as assistant chief of the fuels and lubricants unit of Field Information Agency, Technical. While in the capacity, Sherwood had the opportunity to study German synthetic and natural oil technology.

Sherwood's work and his many facets of technical experience have made him a leading authority in the field of petro-chemical operations.

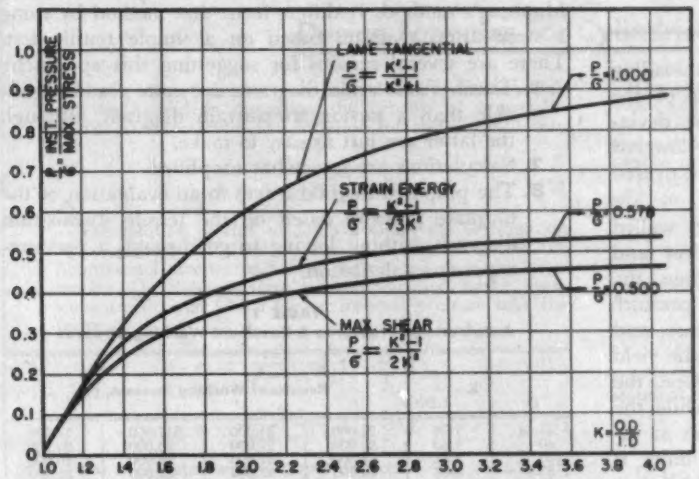


FIGURE 1—Thick walled vessel design formulae plotted to show P/σ versus diameter ratios. The upper curve is for the well known ASME Lamé formula.

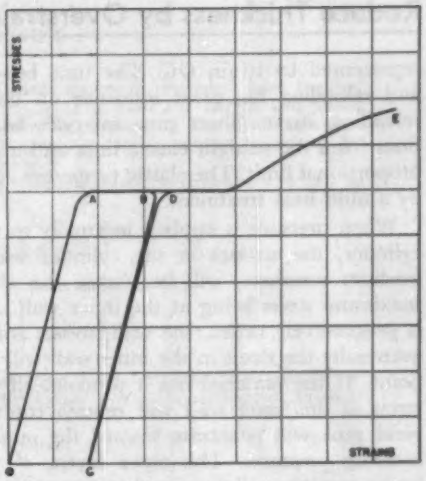


FIGURE 2—Stress-strain diagram showing the resulting stress-strain developed by overstrain.

For thick wall vessels . . .

Reduce Thickness by Overstrain?

The experts call it autofrettage. Here's a method for determining graphically the most advantageous degree of overstrain.

S. M. Jorgensen,
Foster Wheeler Corp., New York City

THE RAPID EXPANSION of the process industries into the high pressure field has presented the vessel designer with a number of new problems. One of the most important problems is the selection of a proper design formula and strength criterion.

In the design of thick-walled cylinders only two strength criteria in the technical literature of today are considered by responsible manufacturers. These are: the shear stress theory and the strain energy theory (von Mises).

Both of these theories are shown on Figure 1, where P/σ is plotted against K, along with the thick wall formula from the ASME code. The thick wall formulas express the maximum pressure occurring at the inside diameter. The Code thick-wall formula is the Lamé formula for the circumferential stress component. For increasing values of K, the Lamé formula deviates considerably from the two other thick-wall formulas. It should be realized, however, that the Lamé formula is used in the Code as representing the ultimate strength of a thick-walled cylinder, although there seems to be no theoretical justification for this being true.

All thick-wall formulas produce curves asymptotic to some finite value of P/σ, which, for instance, in the case of the strain energy theory is $P/\sigma = 0.578$. Present design practice is to limit the stress of the inside wall to a percentage of the yield strength, e.g., 50 percent. For commercially available steels, the allowable stress would be limited to $\sigma \cong 35{,}000$ psi. The pressure, which can be used in monoblock cylinders of conventional design, is therefore limited to $P < 0.578 \times 35{,}000$, or $P < 20{,}000$ psi.

One of the methods proposed to permit higher internal pressures is the use of induced, controlled overstrain in the inner layers of the cylinder, by a method generally known as strain hardening or autofrettage.

Strain Hardening. The mechanism of strain hardening is well known and only a short description will be given. When a ductile material is stretched beyond the yield point it becomes harder, and the effect is an increase of the yield point. Figure 2 shows a stress-strain curve *OAE*, where *A* represents the yield point. After stretching to a point *B*, the pressure is unloaded and during this unloading the material will follow an approximately straight line *BC*. Repeating the loading, the material will follow approximately a straight line *CD*, and will behave as a material with a stress-strain curve *CDE* with a yield point *D*. The material will have a permanent elongation

represented by strain *OC*. The time between unloading and reloading has great influence on the shape of the reloading curve. Short time intervals will cause deviations from the straight elastic lines and a greatly lowered proportional limit. The elastic properties can be recovered by a mild heat treatment.

When pressure is applied internally to a heavy walled cylinder, the stresses in the cylinder wall, at low and medium pressures, will be within the elastic zone, the maximum stress being at the inner wall. As the pressure is progressively raised, the wall stresses will increase, and eventually the stress in the inner wall will reach the yield point. If the material has a pronounced yield zone, the stress at the inner wall will remain constant, while the yield zone will penetrate toward the outer layers at increasing pressures. The outer layers, if the cylinder is heavy enough, will remain elastic.

Continuing the increase in pressure, the inner layer will reach the end of the yield zone and enter the semi-plastic or strain hardening zone, while the yield zone will be displaced toward the outer layers.

If the stress distribution through the wall were to be illustrated graphically during this process of increasing pressures, it would seem as if the stress-strain curve were moving across the wall section from the inside to the outside wall. The strains will grow progressively larger toward the inner wall, and in the yield and semi-plastic zones permanent strains will be at a maximum at the inner wall. On unloading, the permanent deformation of the inner layers will resist the contraction of the outer layers, creating a system of residual stresses, compressive in the inner layers, and tensile in the outer layers. A low temperature treatment to stabilize the elastic properties and the residual stresses completes the autofrettage process.

The autofrettaged cylinder is completely elastic, and can be reloaded to a higher pressure than before, because:

- The residual compressive stresses will counterbalance the working stresses in the inner layers, where the deciding stresses occur.
- The yield points of the inner layers have been increased. Even if the advantage of the higher yield points is ignored, substantial decrease in wall thickness may be permitted.

Method of Calculations. Much of the early development work on autofrettage was done by Macrea,[1] who gave a practical solution to the problem, based on a tensile stress-strain diagram, in which the curves were approximated by straight lines. In spite of these modifications, the method is very cumbersome and time-consuming. A newer method by Manning[2,3] is based on a torsion stress-strain diagram. From an arithmetical integration of the stress-strain curve, Manning obtains a pressure-expansion curve, from which the bore strain and pressure can readily be obtained.

Manning also uses his method for determining the ultimate pressure of a cylinder. This theory has recently been verified by Crossland and Bones[4] in a series of experiments, that show excellent agreement with Manning's theory.

The method proposed in this article is suggested by Manning's method. It differs from that method by using a stress-strain diagram based on a simple tensile test. There are several reasons for suggesting this approach:

1. Tensile stress-strain diagrams are more readily available than a torsion stress-strain diagram, although the latter are just as easy to make.
2. Calculations are somewhat simplified.
3. The proposed method leaves to an evaluation of the ultimate pressure based on the tensile stress-strain diagram, without having to go through a pressure-expansion calculation.

TABLE 1
Autofrettage Pressures & Resultant Working Stresses

D	$K = \frac{D}{I.D.}$	Resultant Working Stresses, psi			
44.44	1.78	23,000	21,000	$17,000	17,000
40	1.60	30,000	27,000	23,000	23,000
36	1.44	34,000	31,000	26,000	26,000
33.3	1.32	40,000	37,000	31,000	31,000
31	1.24	31,000	36,000	35,000	35,000
28	1.12	16,000	21,000	23,000	27,000
25	1.00	9,000	—2,000	1,000	6,000
Autofrettage Pressure, psi.....		65,000	63,000	61,000	59,000

According to Table 1, an autofrettage pressure of 61,000 psi will give the lowest stresses throughout the wall. As the maximum stress, 35,000 psi, equals the specified maximum allowable stress, the assumed wall thickness, 9.72 inch, and the autofrettage pressure, 61,000 psi, is the desired optimum for this vessel, when made of T-1 steel.

The different stresses obtained during the 61,000 psi autofrettage process is shown in Table 2.

TABLE 2
Autofrettage Cycle

D	$K = \frac{D}{I.D.}$	Autofrettage Stresses	Released Stresses	Residual Stresses	Reloading Stresses	Result. Work Stresses
44.44	1.78	53,000	48,000	5,000	12,000	17,000
40	1.60	66,000	59,000	7,000	16,000	23,000
36	1.44	82,000	74,000	8,000	18,000	26,000
33.3	1.32	97,000	87,000	10,000	21,000	31,000
31	1.24	110,000	99,000	11,000	24,000	35,000
28	1.12	113,000	120,000	— 7,000	30,000	23,000
25	1.00	115,000	152,000	—37,000	38,000	1,000

Work Chart Basis. Formulas 1 through 20, (see box) when used with a stress-strain diagram, are sufficient to estimate the stress distribution through a heavy-walled cylinder subject to any amount of overstrain. Used in this fashion, which is similar to Macrea's method, involves a tremendous amount of work, especially if the amount of overstrain is not given.

The amount of work can be reduced by means of a work chart, which must be prepared for each specific steel. Three different steels are shown in this article, with stress-strain diagrams shown in Figure 3.

The work charts are based on a cylinder with a radial ratio $K = 10:1$. For all cylinders with bore radius equal to unity, the radial ratio equals the outside radius. Assume that this cylinder is overstrained, so that the yield point, or the beginning of the yield zone, is located at radius $r_y = K_y = \sqrt{10}$. By means of equations (1) through (20), the stress can be calculated throughout the wall, as shown on the three charts, Figures 4, 5 and 6. As suggested by Manning, the charts are plotted on semi-logarithmic paper, the logarithmic scale used for the radial ratio. This has the advantage, that all cylinders of the same K

Design Formulas For Cylindrical Vessels . . .

Here's a short resume of cylinder design formulas which will be helpful in discussing the benefits of overstrain. Elastic Deformation—The equation for stress equilibrium is:[3]

$$\sigma_t - \sigma_r - r\frac{d\sigma_r}{dr} = 0 \qquad (1)$$

The solution of this equation assumes the deformation to be symmetrical about the axis of the cylinder, and the longitudinal stresses uniformly distributed over the cross section. On these assumptions the so-called Lamé equations are derived which for an internal pressure take the form:

$$\sigma_r = \frac{r_i^2 p}{r_o^2 - r_i^2}\left(1 - \frac{r_o^2}{r^2}\right) \qquad (2)$$

$$\sigma_t = \frac{r_i^2 p}{r_o^2 - r_i^2}\left(1 + \frac{r_o^2}{r^2}\right) \qquad (3)$$

For a cylinder with a closed end there will be a longitudinal stress due to the end load:

$$\sigma_s = \frac{r_i^2 p}{r_o^2 - r_i^2} \qquad (4)$$

The maximum stresses are of particular interest. In the elastic state they occur at the inside wall:

$$\sigma_{r\,max} = -p_i \qquad (5)$$

$$\sigma_{t\,max} = p_i\frac{K^2+1}{K^2-1} \qquad (6)$$

$$\sigma_{s\,max} = p_i\frac{1}{K^2-1} \qquad (7)$$

The magnitude of the principal stress components defines the stress condition throughout the cylinder and also determines the magnitude of the resultant maximum stress, and the ultimate internal pressure.

The maximum stress σ, according to the two prevailing theories, is:

Maximum shear theory: $\sigma_{max} = \sigma_t - \sigma_r$ (8)

Distortion strain energy theory: $\sigma_{max} = \frac{\sqrt{3}}{2}(\sigma_t - \sigma_r)$ (9)

In both of these equations σ is the equivalent simple stress, as determined by the usual tensile test, which will produce a maximum stress equal to that in a test piece subject to all three principal stresses.

The maximum resultant stress, at the inside wall, in the elastic state is obtained by substituting into the two criterion stress equations (8) and (9), formulas (5), (6) and (7):

Maximum shear theory: $\sigma_i = p_i\frac{2K^2}{K^2-1}$ (10)

Strain energy theory: $\sigma_i = p_i\frac{\sqrt{3}K^2}{K^2-1}$ (11)

The maximum shear theory is included here because many engineers use it as a basis for design and vessel acceptance. However, in developing the overstrain formulas and diagrams, only the strain energy theory will be used in the following:

Taking σ_r as a compressive stress, equation (1) can be written:

$$\int d\sigma_r = \int\frac{\sigma_t - \sigma_r}{r}dr \qquad (12)$$

substituting $\sigma_t - \sigma_r$ from equation (9):

$$\int d\sigma_r = \int\frac{2}{\sqrt{3}}\frac{\sigma}{r}dr \qquad (13)$$

One more assumption must be made: that the cross-sectional area of the cylinder remains unchanged, or that:

$$r\delta r = \text{constant} = C = \frac{dr}{r}r^2 = \varepsilon r^2 \qquad (14)$$

In the elastic state:

$$C = \frac{\sigma}{E}r^2 = \frac{\sigma_y}{E}r_y^2$$

If the limiting radii are r_o and r_y then equations (1) and (13) take the form:

$$\int_{\sigma_y}^{\sigma_o} d\sigma_r = \frac{2}{\sqrt{3}}\sigma_y r_y^2\int_{r_y}^{r_o}\frac{dr}{r^3}$$

$$P_{yo} = \frac{\sigma_y}{\sqrt{3}}\left(1 - \frac{r_y^2}{r_o^2}\right) \qquad (15)$$

Yielding. For a material with a pronounced yield zone limited by radii r_y and r_p, the stress is considered constant and equal to σ_y. Equations (1) and (13) then take the form:

$$P_{py} = \frac{2}{\sqrt{3}}\sigma_y \log_e\frac{r_y}{r_p} \qquad (16)$$

The radial stress summation up to radius r_p is:

$$P_{po} = P_{py} + P_{yo} \qquad (17)$$

Strain Hardening. For the strain hardening or plastic zone it is still assumed, that the cross-sectional area of the cylinder remains unchanged. For small strains equation (14) is still valid, but for large strains, the more accurate equation is:

$$\varepsilon(2+\varepsilon)r^2 = \text{constant} \qquad (18)$$

In this zone σ is not a simple function, and equation (1) must be integrated arithmetically:

$$P_{ip} = \frac{2}{\sqrt{3}}\sum_{r_p}^{r_i}\sigma_{av}\frac{\Delta r}{r} \qquad (19)$$

The total radial stress at the inside wall is:

$$P_{io} = P_{ip} + P_{py} + P_{yo} \qquad (20)$$

ratio will be represented by equal lengths throughout the whole logarithmic scale.

With the yield point Y.P. fixed at $r_y = K_y = \sqrt{10}$, the strain at this location is found to be:

$$\varepsilon_y = \frac{\delta r_y}{r_y} = \frac{\text{Y.P.}}{E}$$

According to (14): $\varepsilon_y r_y^2 = C$ (constant).
The strain at any other diameter r_x is then found from:

$$\varepsilon_x = \frac{\delta r_x}{r_x} = \frac{C}{r_x^2}$$

Thus the strain pattern throughout the walls of the 10:1 ratio cylinder can be established. The cylinder wall is divided into a number of sections, and the calculation for the chart is started at the outside radius $r_{10} = 10$. Between r_{10} and r_y the wall is elastic. With the strain at each subdivision established, the stress at each point can be read off the stress-strain curve, or can be found from:

$$\sigma_x r_x^2 = \sigma_y r_y^2 = 10\sigma_y = 10 \times \text{Y.P.}$$

Now the radial pressure summation for the P — curve can be found from (15), which gives the total summation from r_o to r_y. Intermediate points can be found by substituting r_x and σ_x for r_y and σ_y in (15).

For a steel with a pronounced yield the strain is found as for the elastic section, and the stress is of course constant. The P — curve is calculated from (16) and inter-

mediate points at r_x are established by substituting r_x for r_p.

In the plastic zone, the procedure is fundamentally the same. In dealing with the large strains, (18) should theoretically give more acurate results than (14). However, calculating the three charts, Figures 4, 5 and 6, both ways, showed no appreciable change in shape or magnitude of the P — curves, although, the strain at ultimate tensile for A-212 is $\varepsilon_u = 0.28$, which is probably larger than any, that will ever be used in autofrettage work. It would therefore seem, that up to 0.28 strain, the simpler expression (14) is adequate, resulting in less complex calculations.

The strain determination can therefore be continued as before. The stress summation for the P — curve is to be done in accordance with (19). The wall thickness between r_p and r_i is divided into suitable increments. Assume two consecutive division points to be r_m and r_n, the strains at these points to be ε_m and ε_n, and the corresponding stresses, as taken from the stress-strain diagram to be σ_m and σ_n. Then the values to be inserted in (19) are:

$$\sigma_{av} = \frac{1}{2}(\sigma_m + \sigma_n)$$

$$\Delta r = r_m(1 + \varepsilon_m) - r_n(1 + \varepsilon_n)$$

$$r = \frac{1}{2}[r_m(1 + \varepsilon_m) + r_n(1 + \varepsilon_n)]$$

When plotting the three curves, the strained values of P, σ and $\varepsilon = \frac{\delta r}{r}$ should be plotted against the unstrained values of r (or K).

The P and σ curves have been extended beyond the yield point (the dotted lines). This makes it possible to read off stresses released during unloading from the autofrettage pressure, and similarly to find the stresses due to reloading to the working pressure as explained in the following. Thus it is possible to get from the same chart all pertinent data on stresses and strains during all three operations:

1. Overstraining
2. Unloading
3. Reloading to working pressure.

Using the Work Chart. Assume a cylinder with a radial ratio equal to K and draw two vertical lines on the chart, A and B representing the inside and outside radii (see Figure 7). The distance between A and B to be K, as measured on the chart scale. If the cylinder represents a section of a 10:1 ratio cylinder, it is obvious, that the intersection points between A and B and the ε, P and σ curves, represents the radial strain and stress and the equivalent maximum stress at these points. From the form of the equations and the way they are plotted on the charts, it is also obvious that the magnitude of the strain ε at any point K completely determines P and σ. If the assumed cylinder AB is an individual cylinder, and not part of a 10:1 ratio cylinder, with the same strains at A and B, the stresses must be the same. The difference between P-values at A and B in this case represents the internal pressure in the cylinder of inside radius A. The position of the lines A and B determines the amount of overstrain. When B is located to the left of $K = \sqrt{10}$, the whole cylinder is overstrained. When A is located to the right of $K = \sqrt{10}$, the whole cylinder is elastically strained. If $K = \sqrt{10}$ is located between A and B, the cylinder is part elastic, part overstrained.

The problem in autofrettage is to find the optimum condition, for maximum utilization of material and with the maximum stresses within specified limits. Estimating the thickness of an autofrettaged cylinder of a given internal diameter and working pressure is essentially a method of trial and error.

The first step is to make an intelligent guess of the thickness. A good approximation is to calculate a thickness from equation (11) and use 75 to 80 percent of this value as a first approximation. The 75 percent refers to high strength steels (70,000 psi Y.P.), and the 80 percent to medium strength steels (40,000 psi Y.P.).

The second step is to choose a suitable location of the yield point, that is, the degree of overstrain that will produce the minimum stress. A number of calculations have shown, that for medium strength steels the optimum condition generally occurs, when the mean geometric diameter, $\sqrt{\text{I.D.} \times \text{O.D.}}$, is stressed to the initial yield point. For high strength steels, the optimum condition will occur when the overstrain penetrates to a diameter slightly smaller than the mean geometric. The first try would then be to locate the yield point at the mean geometric diameter, and if subsequent tries are required, to move the yield point toward the inside diameter. If the minimum stress thus found does not agree with the specified allowable stress, then another set of trial and error calculations must be made with a different wall thickness.

If the thickness is assumed as suggested above, it is seldom necessary to try for a different thickness. The

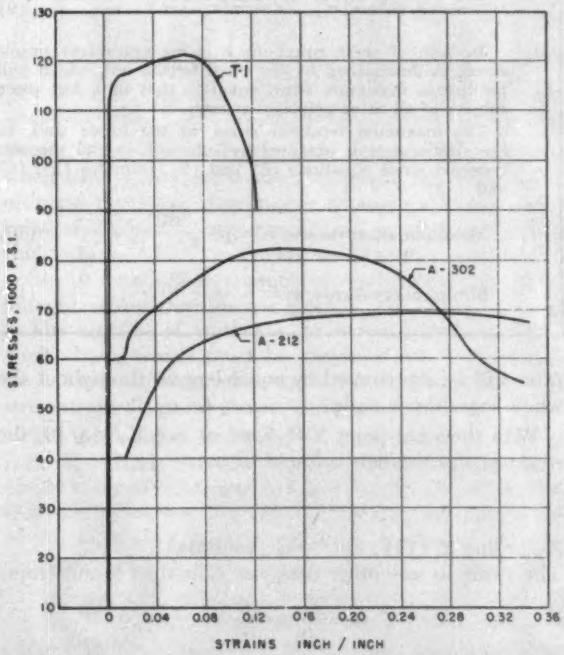


FIGURE 3—Stress-strain diagrams for three common steels used in vessel design.

main problem then is to try for the degree of overstrain. This part is very easily done by means of the work chart, and generally 3 or 4 tries for the location of the yield point are sufficient. Rather than draw lines on the chart, use a piece of transparent paper. Draw two vertical lines on the paper, representing the I.D. and O.D. of the assumed cylinder wall, the scale of the distance between the lines to be the same as the logarithmic abcissa scale on the work chart. The line on the left, $K_{ID} = 1.0$, represents the inside diameter, the line on the right, $K_{OD} =$ O.D./I.D., represents the outside diameter. A third line centered between these two represents the location of the yield point for the first try. Draw four more vertical lines equidistant between the existing three lines, and note their K values. Now draw a horizontal line, called the top line, at right angles to the vertical lines. Place the paper on the work chart, with the intersection point, K_{ID} — top line, on the plastic P — curve, Draw a horizontal line, called the bottom line, through the intersection point between the K_{OD} line and the P — curve. The vertical distance between top and bottom lines, when measured on the pressure-stress scale, equals the autofrettage pressure. The intersections between the vertical lines and the plastic-elastic σ-curve, represent the equivalent autofrettage stresses, at the diameters corresponding to the K numbers on the paper, and can be read directly off the stress scale.

Now move the paper to the right, the intersection point, K_{OD} — bottom line, riding on the P — curve, until the intersection point, K_{ID} — top line, hits the elastic P — curve (dotted line). The intersections between the vertical lines and the all elastic σ-curve, represent the equivalent released stresses, at the diameters corresponding to the K numbers on the paper, and can be read directly off the stress scale.

The residual stresses are the differences between the autofrettage and the released stresses.

Draw a horizontal line, the reloading line, on the transparent paper at a distance below the top line equal to the working or design pressure of the cylinder. Place the paper on the work chart, so that the P — curve passes through the intersection points K_{ID} — top line and K_{OD} — reloading line. The intersections between the vertical lines and the σ-curve represents the equivalent reloading stresses and can be read directly off the stress scale.

The resultant working stresses are the sum of the residual and the reloading stresses. If the resulting stresses are above the specified minimum stress, another try is to be made, with lower degree of overstrain. This can be done with the same transparent paper by drawing another bottom line above the first one, at a distance, for instance, of 2000 psi, and then repeat the above proceedings. This to be repeated until the minimum stress has been found.

Here's an Example. Assume a cylinder made from T-1 steel, and to the following specifications:

I.D. = 25 inch inside diameter

$P_i = 15{,}000$ psi design and working pressure

$\sigma_i = 35{,}000$ psi maximum allowable stress

Substituting the values for P_i and σ_i in (11), $K =$ 1.97, corresponding to a wall thickness equal to 12.15 inches. Assuming 80 percent (9.72 inch) to be the autofrettaged wall thickness, the resulting O.D. = 44.44 inch and corresponds to $K = 1.78$. The mean geometric

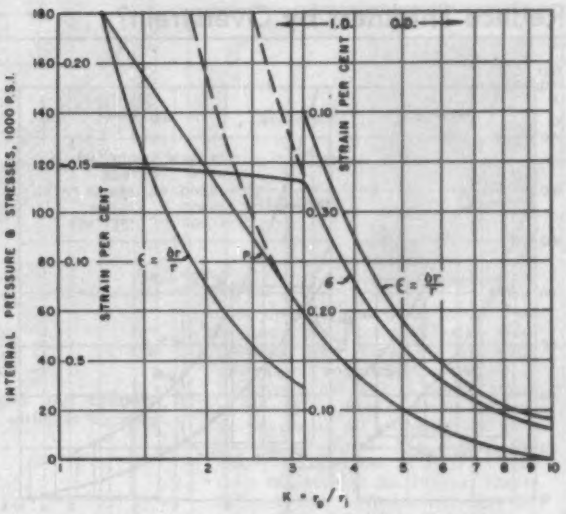


FIGURE 4.

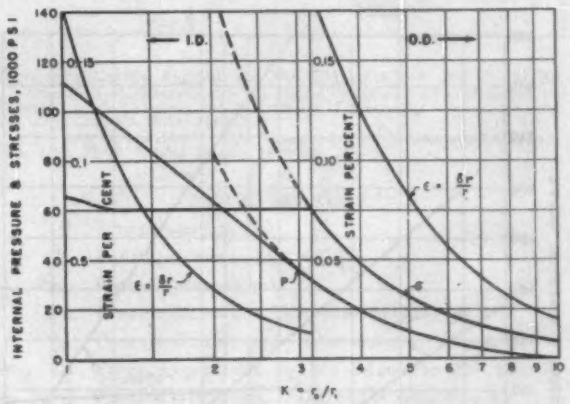
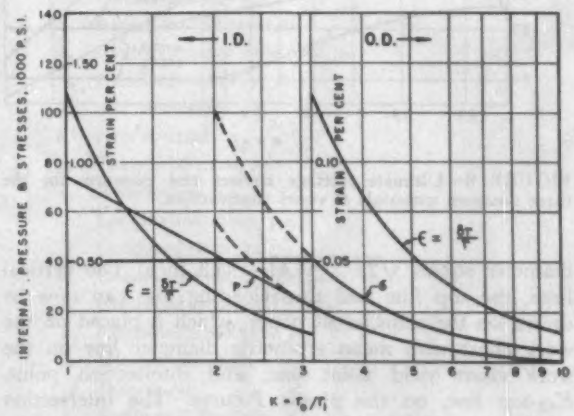


FIGURE 5.



FIGURES 4, 5, and 6.—Autofrettage work chart for T-1 steel . . . (Fig. 4), A-302 steel (Fig. 5) and A-212 steel (Fig. 6). By plotting on semi-log paper, the logarithmic scale permits all cylinders of the same K ratio to be represented by equal lengths throughout the whole scale.

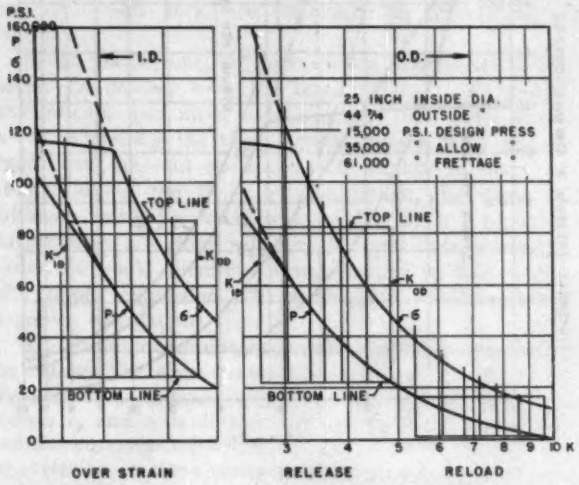


FIGURE 7—Work chart for the autofrettage calculation. The most advantageous degree of overstrain with a resulting release and reload are determined from this work chart.

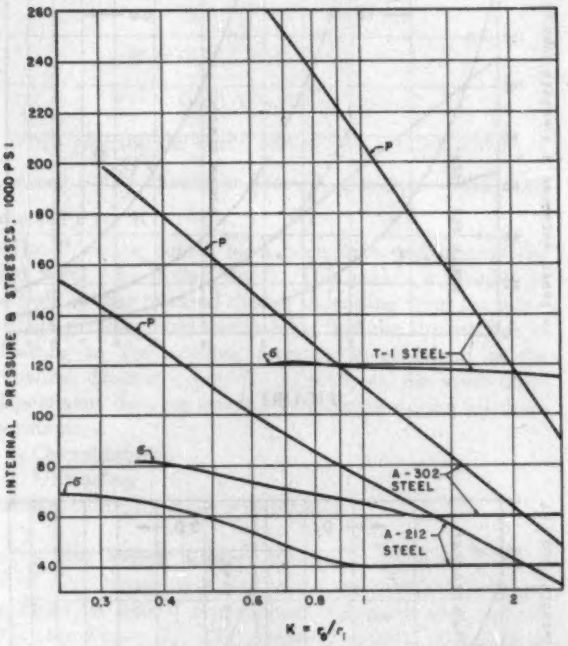


FIGURE 8—Ultimate frettage stresses and pressures for the three common materials of vessel construction.

diameter equals $\sqrt{25 \times 44.44} = 33.3$ inch. The vertical lines, the top line and the reloading line can now be drawn on the transparent paper, which is placed on the work chart with mean geometric diameter line on the work chart yield point line, and intersection point, K_{ID}-top line, on the plastic P-curve. The intersection between the K_{OD} line and the elastic P-curve locates the bottom line, which for this location indicates an autofrettage pressure of 65,000 psi. Three additional bottom lines are drawn for 63, 61 and 59,000 psi autofrettage pressures. Table 1 shows the resultant working stresses for these four different autofrettage pressures.

The positions of the line diagram on the work chart producing the autofrettage, released and reloading stresses are shown on Figure 7.

Ultimate Strength. It has been shown that for any given value of K, the internal pressure P can be found by an arithmetical integration of (13), when the strain or stress at one point in the cylinder is assumed known. When higher and higher values of the stresses are assumed, the value of P will pass through a maximum. Manning postulated, that this maximum is the ultimate or bursting pressure of the cylinder, and this theory is amply supported by Crossland and Bones. As Manning used the stress-strain curve from a torsion test, the ultimate pressure could not be related to the usual mechanical properties of the material.

From the work chart procedure for finding internal pressure, it is obvious, that the maximum value of P, for a given K ratio, must occur, when the sliding line diagram reaches a point on the P— curve, where it starts a downward slope. Figure 8 shows the upper range of the P — and σ-curves of the work charts of the three materials previously described. It will be noticed, that the downward slope of the P— curve starts at or near the ultimate strength of the material. It is therefore postulated, that bursting will occur, when the stress at the inside diameter reaches the ultimate.

The distance between two verticle lines drawn on Figure 8 (K_{ID} through the point of maximum stress and K_{OD} to the right of K_{ID}) measured on the abscissa scale will represent the K ratio for a certain cylinder. The vertical distance between the intersections of the two lines with the P— curve will represent the bursting pressure of the cylinder. Figure 9 shows the bursting pressures plotted against different K ratios for three materials.

The postulated bursting criterion can be used as a basis for an empirical formula for the ultimate or bursting strength of a cylinder. First a formula must be developed for the strained diametrical ratio K'. From the expression (18) for large strains:

$$\varepsilon_o(2+\varepsilon_o) = \frac{\varepsilon_u(2+\varepsilon_u)}{K^2}$$

Also:
$$K' = K\frac{1+\varepsilon_o}{1+\varepsilon_u}$$

Eliminating ε_o:
$$(K')^2 = 1 + \frac{K^2-1}{(1+\varepsilon_u)^2} \qquad (21)$$

This expression is shown graphically in Figure 10.

Several expressions for an empirical bursting pressure were considered and compared with the values obtained from Figure 9. The first formula:

$$P_{ULT} = \frac{2}{\sqrt{3}}\sigma_u \log_e K' \qquad (22)$$

shows too high values for P_{ULT} for large values of K'. Another try was:

$$P_{ULT} = \frac{2}{\sqrt{3}}\sigma_m \log_e K' \qquad (23)$$

$$\sigma_m = A/(\varepsilon_u - \varepsilon_e)$$

where A equals the area under the stress-strain curve

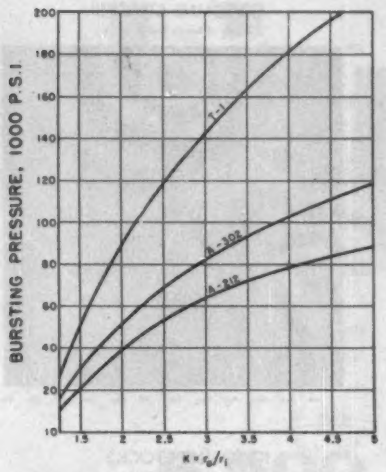


FIGURE 9—Bursting pressures for three materials plotted against radius ratios.

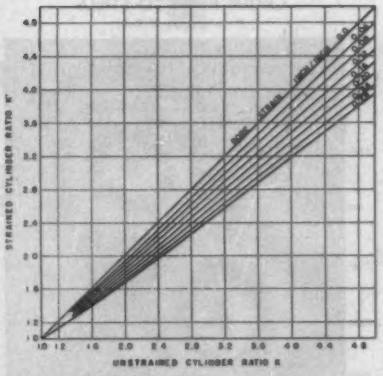


FIGURE 10—Bore strains and cylinder ratios for computing the ultimate bursting strength.

between ordinates through ε_u and ε_o. This formula showed similar deviations as the previous one although to a smaller degree.

The final formula is:

$$P_{ULT} = \frac{2}{\sqrt{3}} \frac{\sigma_u + \sigma_o}{2} \log_e K' \qquad (24)$$

The outside wall stress, σ_o, is taken from the stress-strain diagram. The corresponding strain is:

$$\varepsilon_o = \frac{K'}{K}(1 + \varepsilon_u) - 1$$

Table 3 shows the bursting pressures in accordance with the three equations and Figure 9.

TABLE 3
Bursting Pressures for Different Equations

K	BURSTING PRESSURES, PSI			
	Eq. (22)	Eq. (23)	Eq. (24)	Fig. 9
T-1				
1.5	54,000	54,000	54,000	52,000
2	91,000	90,000	90,000	90,000
2.5	121,000	119,000	119,000	119,000
3	146,000	143,000	143,000	143,000
3.5	168,000	164,000	164,000	164,000
4	186,000	180,000	180,000	182,000
4.5	202,000	195,000	195,000	196,000
5	217,000	204,000	204,000	208,000
A-302				
1.5	30,700	29,400	29,600	30,000
2	56,300	54,900	52,200	52,000
2.5	76,000	73,300	68,800	69,000
3	92,500	88,700	81,000	82,000
3.5	106,500	102,000	92,000	94,000
4	119,000	114,000	103,000	103,000
4.5	130,000	124,000	112,000	111,000
5	140,000	134,000	121,000	119,000
A-212				
1.5	22,400	22,000	22,000	21,000
2	41,200	40,500	39,500	39,000
2.5	57,200	55,500	53,000	53,000
3	70,500	67,500	61,000	64,000
3.5	82,000	78,000	68,000	72,000
4	92,500	87,000	76,000	78,000
4.5	102,000	96,000	81,000	84,000
5	110,000	104,000	87,000	89,000

Equation (24) shows very good agreement with Figure 9. The deviations are within the limits of accuracy used in the calculations.

About the Author

S. M. Jorgensen is mechanical engineer for Foster Wheeler Corporation, New York. He has done mechanical engineering for firms in Europe and the United States mainly in the field of prime movers, power plants, oil refineries and petrochemical plants. He joined the Foster Wheeler Co. in 1937 as contract engineer in the Process Plants division and is presently engaged primarily in research and development of vessels and other equipment for high pressures. Jorgensen is a graduate of the Royal Technical College, Copenhagen, where he received a B.S. degree in mechanical engineering in 1922.

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[2] "The Overstrain of Tubes by Internal Pressure" by W. R. D. Manning, Engineering. London, England. Vol. 159, 1945, pp. 101-102, 183-184.

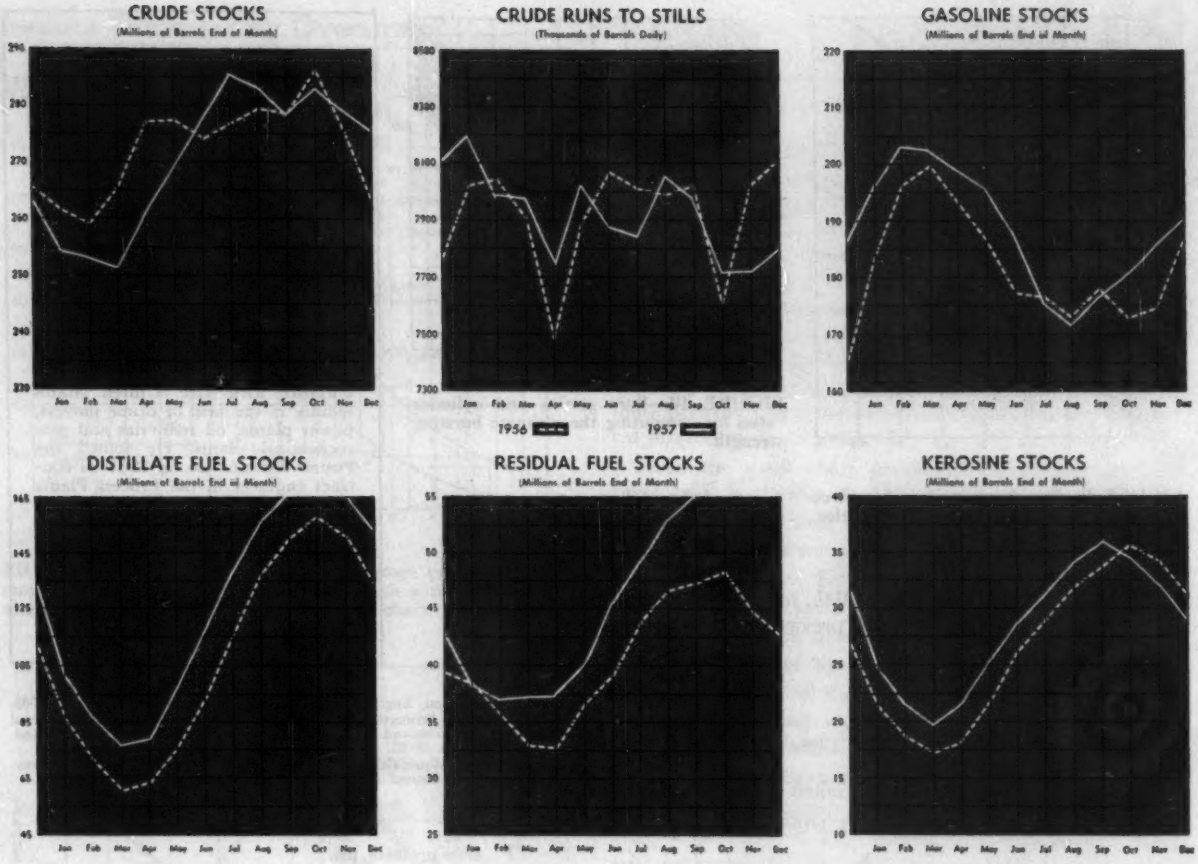
[3] "The Design of Cylinders by Autofrettage" by W. R. D. Manning, Engineering. London, England. Vol. 169, 1950, pp. 479-481, 509-511, 562-563.

[4] "The Ultimate Strength of Thick-Walled Cylinders Subjected to Internal Pressure" by B. Crossland and J. A. Bones, Engineering. London, England. Vol. 179, 1955, pp. 80-83, 114-117.

[5] "Strength of Materials" by S. Timoshenko, D. VanNostrand Company. New York, N. Y. Second Edition, 1941, pp. 236-241.

NOMENCLATURE

P	Bore pressure, psi.
P_i	Radial pressure at I.D., psi.
P_{ULT}	Bursting pressure, psi.
P_{yo}	Pressure summation, yield point to O.D., psi.
P_{pY}	Pressure summation, initial to end of yield zone, psi.
P_{po}	Pressure summation, end of yield zone to O.D., psi.
P_{ip}	Pressure summation, I.D. to end of yield zone, psi.
P_{io}	Pressure summation, I.D. to O.D., psi.
r	Radius to any point, in.
r_i	Inside radius, in.
r_o	Outside radius, in.
r_y	Radius to yield point, in.
r_p	Radius to end of yield zone, in.
r_x	Intermediate radius, in.
K	r_o/r_i unstrained
K'	r_o/r_i strained
σ_t	Tangential stress, psi.
σ_r	Radial stress, psi.
σ_o	Longitudinal stress, psi.
σ	Combined stress, psi.
σ_i	Combined stress at I.D., psi.
σ_y	Combined stress at Y.P., psi.
σ_x	Combined stress at r_x, psi.
σ_u	Ultimate stress, psi.
ε	$\delta r/r$, in./in.
ε_y	Strain at Y.P., in./in.
ε_x	Strain at r_x, in./in.
ε_o	Strain at r_o, in./in.
ε_u	Strain at σ_u, in./in.
E	Coeff. of elasticity 30×10^6, psi



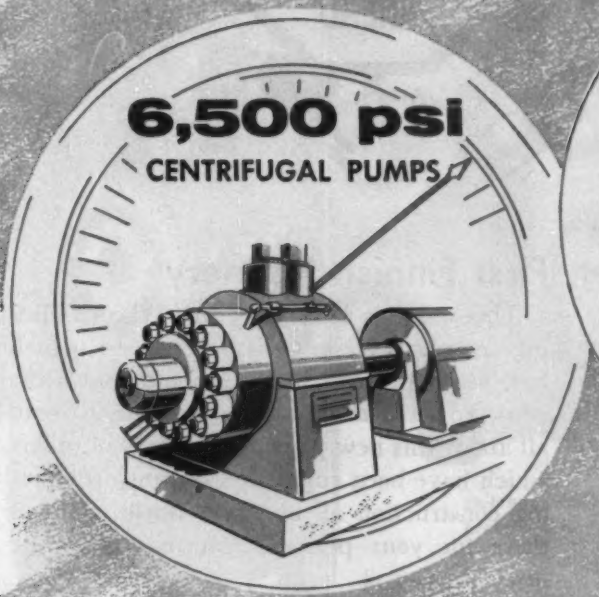
Taking Stock

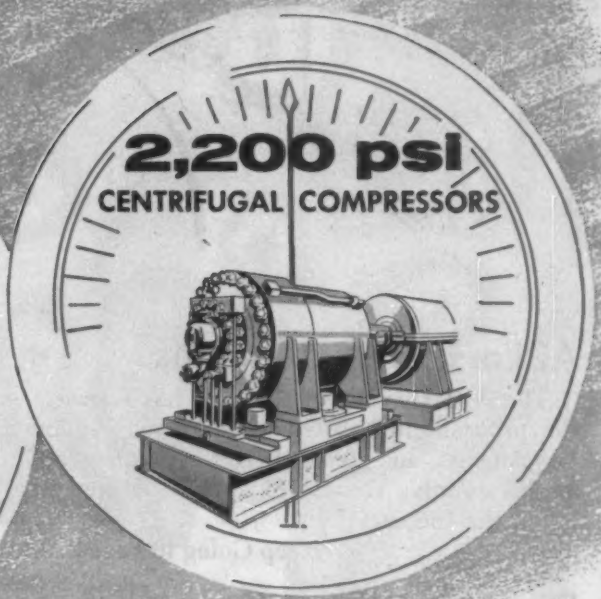
- Gasoline Stock Growth Eases
- Oil Imports Highest Since August
- Fuel Oil Inventories Dropping

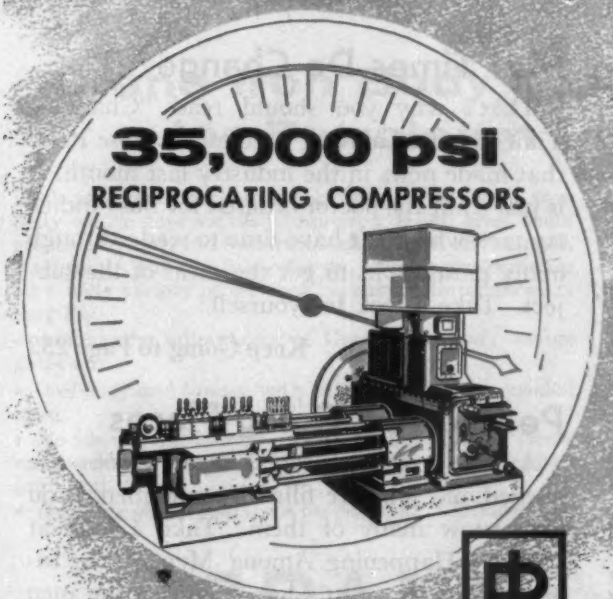
MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1955:													
November	7,014	7,692	260,707	3,867	157,871	341	33,283	1,680	141,808	1,214	44,071	823	1,322
December	7,155	7,762	265,610	3,916	165,433	395	26,770	1,765	111,333	1,286	39,174	884	1,502
1956:													
January	7,199	8,023	261,592	3,927	183,905	385	21,310	1,923	86,141	1,344	38,247	805	1,422
February	7,208	8,047	259,504	3,854	196,092	385	18,712	1,918	71,335	1,286	35,673	878	1,472
March	7,278	7,914	265,683	3,829	199,698	342	17,215	1,808	60,846	1,213	32,984	934	1,425
April	7,146	7,487	277,121	3,646	193,299	299	18,227	1,713	63,571	1,130	32,740	815	1,305
May	7,064	7,896	277,497	3,859	186,673	292	21,883	1,667	75,928	1,149	36,607	938	1,416
June	7,100	8,071	274,491	3,976	177,076	290	26,111	1,755	93,758	1,098	39,073	987	1,426
July	7,090	8,014	277,008	3,975	176,536	296	28,990	1,767	115,787	1,066	43,958	1,084	1,463
August	7,195	7,995	279,944	4,037	172,939	313	31,826	1,839	137,905	1 091	46,617	1,001	1,399
September	7,054	8,024	278,791	3,991	177,974	329	33,588	1,345	150 411	1,062	47,342	1,043	1,452
October	6,966	7,608	286,560	3,773	172,798	356	35,667	1,772	158,871	1,082	48,400	1,004	1,541
November	7,139	8,031	275,995	3,913	174,808	384	34,329	1,841	151,517	1,182	44,590	871	1,362
December	7,377	8,141	266,014	4,039	187,271	379	31,420	1,981	133,981	1,288	44,491	873	1,471
1957:													
January	7,480	8,274	256,669	3,991	197,702	367	24,019	2,118	100,572	1,322	38,403	805	1,425
February	7,682	8,088	256,344	3,864	205,270	353	21,013	2,035	85,105	1,270	31,201	780	1,430
March	7,717	8,047	254,911	3,826	206,716	332	20,223	1,861	76,245	1,205	37,371	836	1,464
April	7,541	7,740	265,796	3,770	201,407	284	21,512	1,764	78,743	1,132	37,429	906	1,542
May	7,442	7,992	275,963	3,900	195,094	272	25,545	1,789	98,135	1,103	41,125	1,042	1,558
June	7,107	7,867	284,312	3,984	190,063	254	28,872	1,773	117,364	1,101	45,572	1,147	1,606
July	6,873	7,852	288,241	3,887	177,868	249	31,713	1,750	138,359	1,090	49,621	1,220	1,654
August	6,786	8,092	283,388	4,122	174,031	252	34,576	1,806	159,124	1,089	52,645	1,257	1,695
September	6,887	7,920	280,469	4,099	180,688	276	36,382	1,772	173,269	1,100	58,727	1,042	1,445
October	6,860	7,650	284,517	3,939	180,902	265	34,384	1,705	176,388	1,052	60,025	1,022	1,532
November	6,824	7,717	279,725	3,830	186,027	300	32,267	1,744	166,323	1,066	58,816	892	1,387
December	6,895	9,803	276,561	3,935	190,295	345	28,997	1,874	153,517	1,111	58,191	1,045	1,619
Week Ended:													
1-17-58	6,925	7,675	277,065	3,818	200,636	387	25,343	1,962	135,406	1,019	57,952	713	1,361
1-18-57	7,431	8,120	256,278	3,854	191,373	353	27,542	2,120	114,424	1,275	41,009	825	1,403

Source: Data, for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

hi-psi *







These gauges show high levels of gas and liquid pressures created by machines designed and built by Ingersoll-Rand.

Such pressures have not always been practical. Most top levels have crept up little by little as new processes in industry demanded higher and still higher pressures. Those indicated here are bold advances, much higher than the preceding highs. Each is another building block in the foundation of experience.

Through a half century of such experience Ingersoll-Rand has been closely associated with the process and petrochemical industries. If you need to compress a gas, or pump a liquid at any pressure you choose to call high, take advantage of Ingersoll-Rand's experience that has continuously set the pace in high-pressures.

* **hi-psi** . . . high pressures, measured in pounds per square inch.

Ingersoll-Rand

I-681 11 Broadway, New York 4, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.

API'ers To Los Angeles

The API Division of Refining has released the program for its semi-annual meeting in Los Angeles, and its all there for you to read in this month's account of "What's Happening in the Industry."

Keep Going to Page 220

Easier Solutions

It's easy to find the capacity of your vertical cylindrical tanks. You will learn the seven easy steps in doing this by reading this month's interesting and informative lead article in "How To Do It."

Keep Going to Page 174

When, Where, and What

A "must read" for every man in the industry is the "Meetings Calendar." It's an easy-to-read tabulation of what's coming up in the organizations and societies that are of most interest to you.

Keep Going to Page 234

You Should Know

"What Suppliers Are Doing" is the department where you will find information you need to know about the companies that supply the refining-petrochemical-natural-gasoline industry. This handy guide will help you keep up with the people who serve your plant, and any extension of facilities which will be of service to you.

Keep Going to Page 251

First Finnish Refinery

This month's lead story in "Who's Building" concerns Neste Oy's new refinery which has just gone on stream in Finland, and is the world's northernmost refinery. You'll read all about this new plant plus dozens of others which have been completed or are just starting construction all over the world. It's all there for your personal information, so be sure that you . . .

Keep Going to Page 182

My! Times Do Change

That's why you should read "Changing Times," a fast moving account of those items that made news in the industry last month. It is just what the doctor ordered for busy industry men who don't have time to wade through many paragraphs to get the meat of the subject. Take a look for yourself!

Keep Going to Page 232

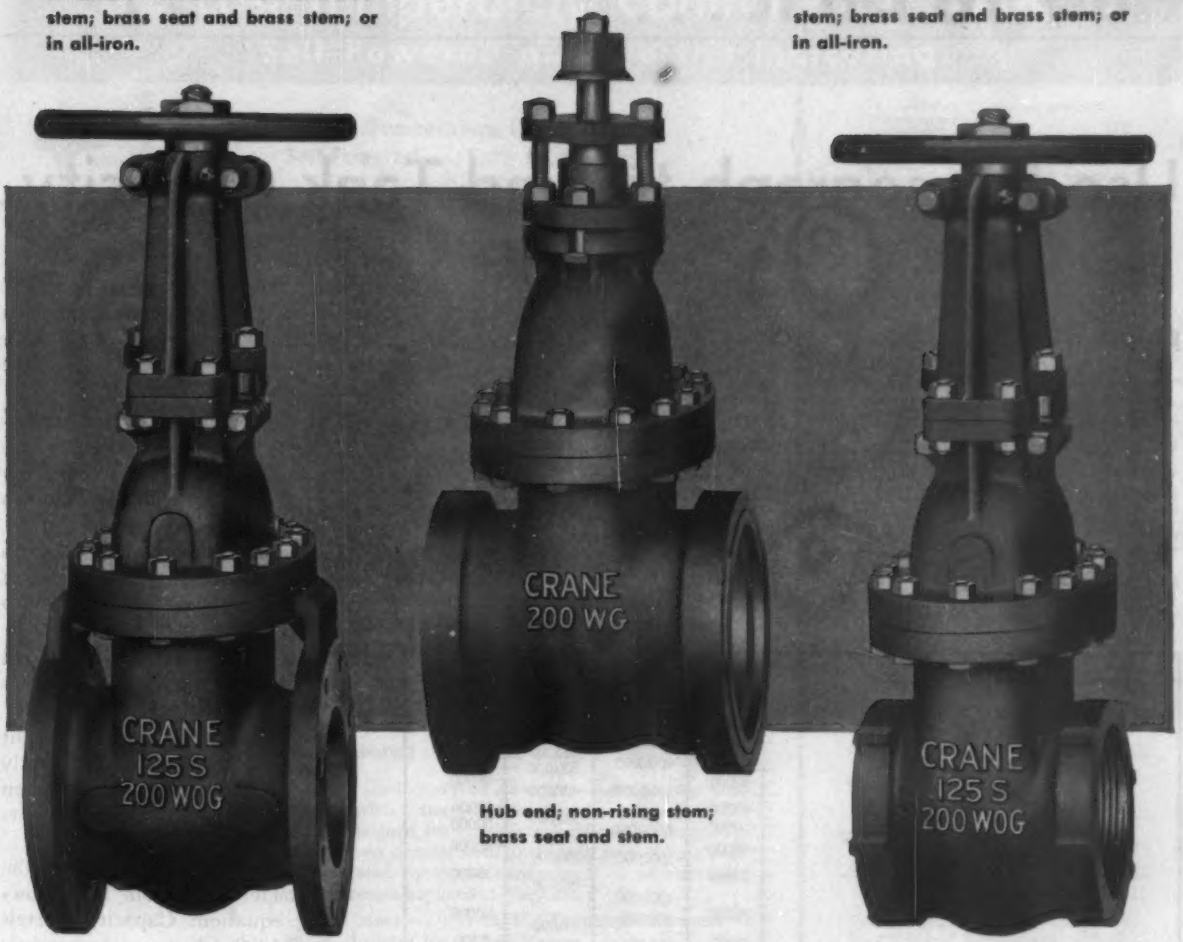
People Are Going Places

As the industry progresses, new jobs are opened, old jobs are filled by new men. You may know many of them. Take a look at "What's Happening Among Men in the Industry" to see what's happening to the men you know—and those you would like to know.

Keep Going to Page 239

Flanged end; outside screw and yoke. Available with brass seat and steel stem; brass seat and brass stem; or in all-iron.

Screwed end; outside screw and yoke. Available with brass seat and steel stem; brass seat and brass stem; or in all-iron.



Hub end; non-rising stem; brass seat and stem.

Crane Iron Body Gates–Versatile Valves for Petroleum Industry Services

Look to Crane for better performing 125-pound iron body wedge gate valves. Improved design gives them greater strength and important operational advantages. As a result, these valves offer dependable performance on a wide variety of services . . . easy maintenance . . . long life.

Among the advantages of Crane iron body wedge gates are:

- *Oval body and bonnet*, with extra metal where needed most.
- *No bonnet joint leakage*—More bonnet bolts on closer centers insure uniform bolt load distribution on bonnet joint and gasket.
- *Long disc guides* seat discs properly . . . minimize drag on seating surfaces . . . prolong valve life.
- *Shoulder-type seat rings* prevent rings from loosening in service.
- *Two-piece ball-type gland* prevents binding on stem even when gland bolt nuts are pulled up unevenly.
- *Exceptionally deep stuffing box* can easily be repacked under pressure when valves are wide open.
- *Available in 19 sizes*—2 inches to 48 inches—all-iron or brass trimmed. In addition, Crane makes companion valves in globe, angle, check, quick-opening and Underwriters' patterns.

For complete descriptions of Crane iron body gate valves, consult your Crane Representative, or write to Crane Co. at the address shown below.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

Since 1855 — Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers Serving All Areas

For more data on advertised products, use Readers' Service Cards, last page.

How To Do It . . .

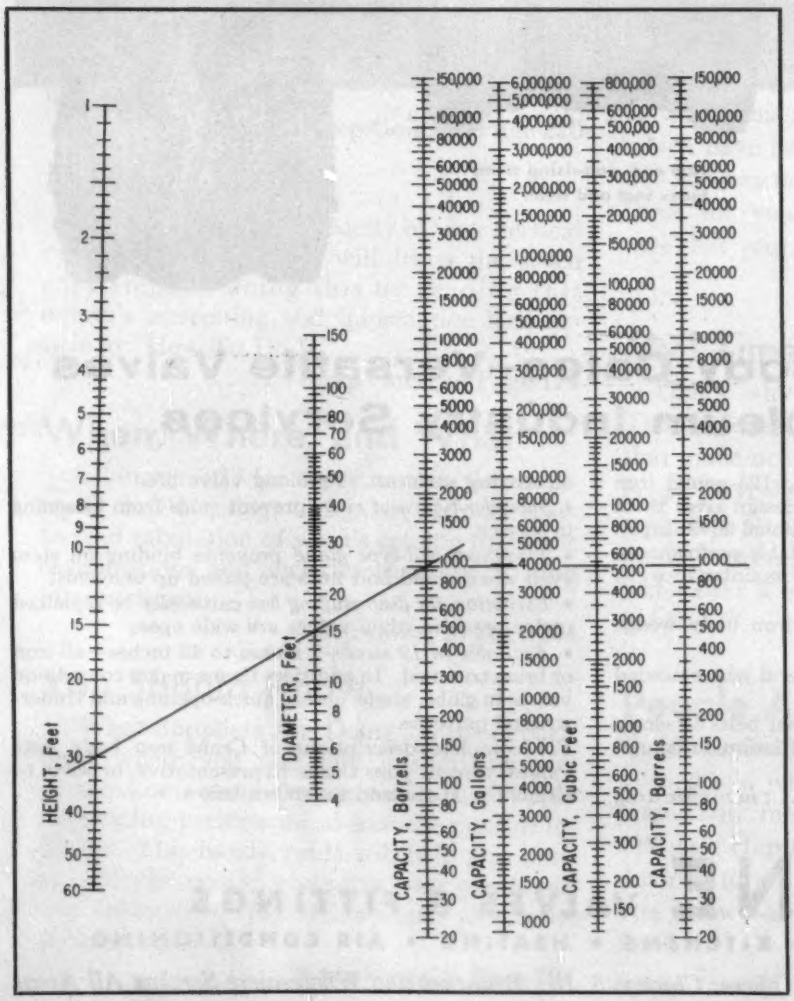
Use Nomograph to Find Tank Capacity

If you know the tank height and diameter, this graph will solve your problems.

This simple nomograph can be used to find the capacity of your vertical cylindrical tanks. Here's how it works:

Draw a straight line from the "height" scale through the "diameter" scale and to the first "capacity, barrels" scale. Read directly the capacity of the tank in barrels. (Note: The "height" scale may be used to indicate the overall height of the tank or the depth of liquid in the tank.)

Draw a second straight line connecting the two "capacity, barrels" scales at the same reading on each scale. Read the capacity of the tank in gallons and cubic feet on the proper scales.



The nomograph was constructed as follows:

1. The "height" scale is based on two log cycles per ten inches with a range of 1 to 60 feet.
2. The "capacity, barrels" scale is based on four log cycles per ten inches with a range of 20 to 150,000 barrels.
3. The "diameter" scale is based on three log cycles per ten inches with a range of 4 to 150 feet.
4. The distance between the height and diameter scales is exactly two-thirds the distance between the height and "capacity, barrels" scale.
5. Determine points to locate the diameter scale from the following equation: Capacity, barrels $= 0.1399$ (diameter)^2 (height), units in feet.
6. The "capacity, gallons" scale is based on four log cycles per ten inches. The initial point on the scale is determined as follows: 20 barrels x 42 gallons per barrel = 840 gallons. The range of the scale is 900 to 6 million gal.
7. The "capacity, cubic feet" scale is based on four log cycles per ten inches. The initial point on the scale is determined as follows: 20 barrels x 5.6146 cubic feet per barrel = 112.292 cubic feet. The range of the scale is 120 to 800,000 cubic feet.

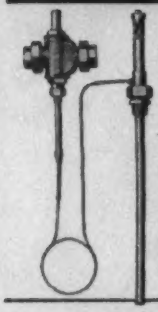
Item submitted by: Marvin H. Green, Philadelphia.

Dope Heater from Scrap

Where wrapped and coated sections of pipes are being erected or where dope is needed for roofs, etc., it is always necessary to have a portable dope heater. One refinery fore-

Low-cost Temperature Control — by SARCO

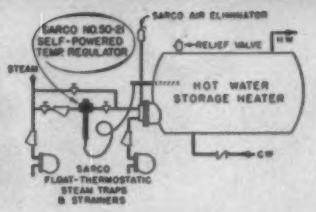
Self-Powered and Electric Indicating



Sarco Temperature Controllers
Self-Powered . . . Fully Modulating

Simple as ABC . . . a thermostat with capillary tubing and a valve. That's all! Operated by liquid expansion. Automatic. Self-powered . . . no electricity or compressed air required. Self-contained . . . no exposed mechanism. Packless valve . . . no stuffing box to leak or stick. Easy to install by any pipefitter.

Furnished with thermostats suitable for any liquid or for air in dryers, ovens, air ducts, etc. Valve sizes . . . ½ to 6". Temperature ranges to 300°F. *Bulletin 620-2.*

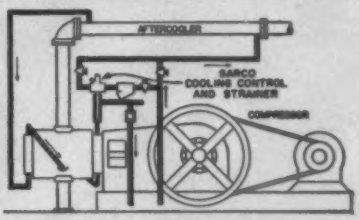


Typical applications: Shell and tube heat exchangers; condensers, oil storage tanks, dryers, etc.

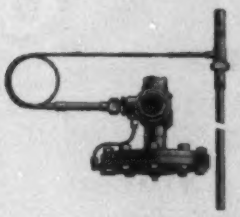
Sarco Cooling Controls
Self-Powered . . . Fully Modulating

Simple, compact, automatic thermostatic valve. Eliminates overcooling and undercooling. Saves water. Overall height of ¾" size is only 17⁷⁄₁₆". Self-powered . . . requires no electrical or compressed air hook-up. Valve and bulb all in one unit. No exposed mechanism. Single-seated packless valve . . . not affected by silt or scale-forming minerals.

Valve sizes . . . ⅜ to 1½". Temperature ranges between 40° and 210°F. *Bulletin No. 710-B.*



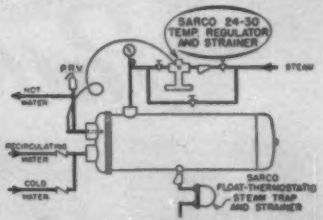
Typical applications: compressors, small engines, water-cooled bearings, condensers, dry cleaning stills, etc.



Sarco Temperature Controllers
Self-Powered . . . Single-Seated, Tight-Closing

A simple, self-powered automatic temperature controller with diaphragm-operated, pilot-controlled valve. Designed for intermittent service or service involving long periods with practically no call for steam. Self-powered by liquid expansion . . . no electricity or compressed air needed. Packless.

Valve sizes . . . ½ to 3". Temperature ranges to 300°F. *Bulletin No. 625-B.*

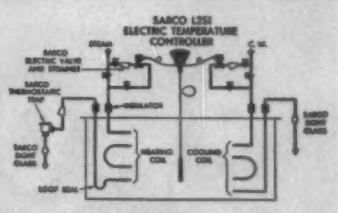


Typical applications: Instantaneous heaters, fuel oil pre-heaters, high pressure applications on hot water storage tanks.

Sarco Electric Temperature Controllers
Indicating Type

Simple, inexpensive, electric-indicating automatic temperature controller. Sensitive enough to perform many of the functions of much more elaborate recorder-controllers, at a fraction of their cost. Responds to changes of ± ½°F. Adjustable. Large, easy-to-read scale shows both actual and set temperatures.

Temperature ranges between minus 90° and plus 650°F. Offers many sequence combinations such as step-heating. *Bulletin 1025-B.*



Typical applications: plating tanks, processing vats, kettles, chemical tanks, etc.

Sarcostat Hydraulic Motor Valves
Electrically Operated

For remote control by hand or thermostat. Open and shut operation. Can be equipped with semi-modulating mechanism. Powerful hydraulic action operates valves up to 5" single-seated, or 8" double-seated, at pressures up to 175 psi. Ruggedly constructed . . . to withstand severe use without constant supervision and with minimum maintenance. Operates in any position.

For direct connection to 110 volts A. C., 60 cycle current. Valve sizes . . . ½ to 5" single-seated; ½ to 6" double-seated. *Bulletin 1080-A.*

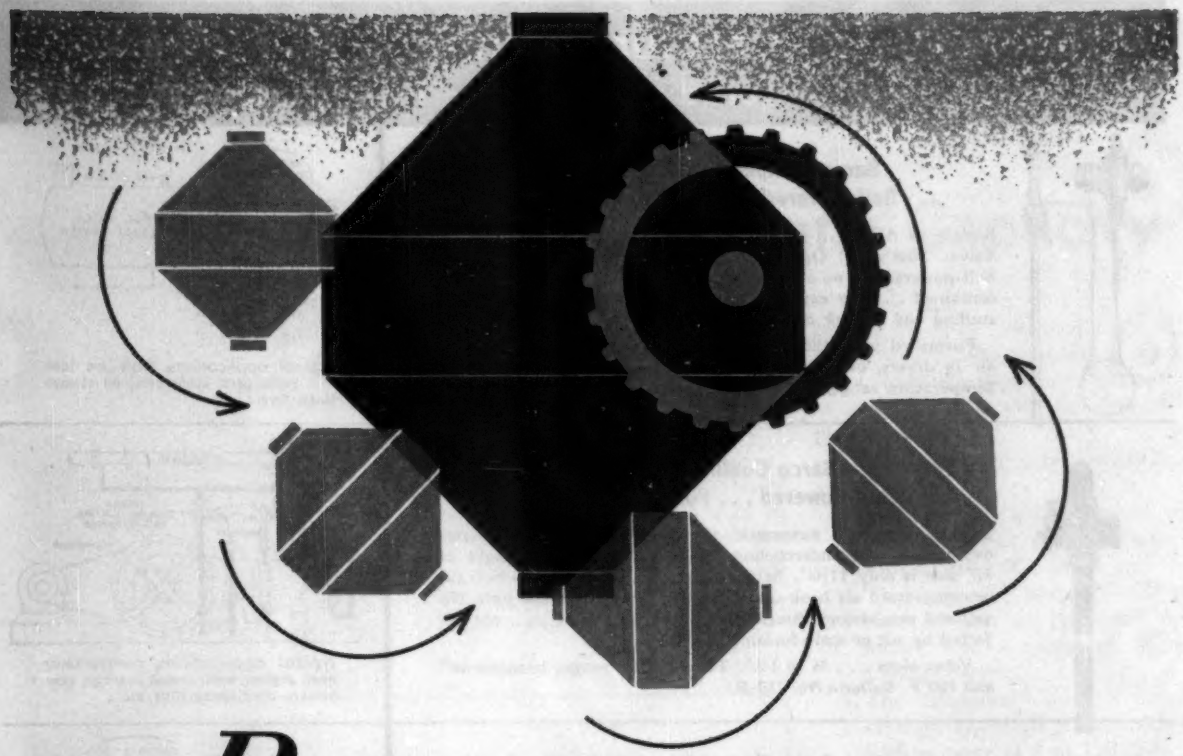
UNDIVIDED RESPONSIBILITY

From one "Complete Line" source . . . SARCO-SARCOTHERM . . . for temperature controllers, steam traps and other heating specialties.

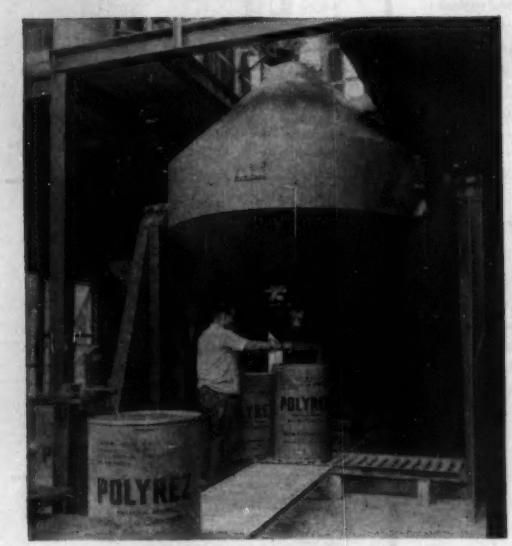
2230-B

Write for Bulletins to — Sarco Co., Inc., 635 Madison Ave., New York 22, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.



Patterson gives POLYREZ 70% REDUCTION IN BLENDING TIME with the famous THORO BLENDER®



This deep cut in processing time represents for Polyrez Company, Woodbury, New Jersey, the difference between earlier spiral blending of phenolic resins and today's rapid ThoroBlender operation. Previous production difficulties included product caking and loading limitations. Now, very large batches of completely homogeneous blends are obtained in record time with the ThoroBlender, even with additives as small as 2%. For fast, gentle, thorough mixing—independent of flow properties of your material or variations in particle size—put the Patterson ThoroBlender to work in your plant. A Patterson engineer will be glad to arrange for test blending of your materials in our laboratory and discuss the data with you. Write.

ADVANCED PROCESS EQUIPMENT OF ENDURING SATISFACTION

THE Patterson FOUNDRY AND MACHINE COMPANY

A Subsidiary of Ferro Corporation

East Liverpool, Ohio

THE Patterson FOUNDRY AND MACHINE COMPANY (CANADA) LIMITED

Toronto, Ontario

man made an efficient heater from scraps of material which can usually be found around the refinery junk yard.

The fuel container was made from a two foot section of 12-inch pipe, and the heater and dope container were made from a 30-inch nipple of 16-inch pipe, with a false bottom so that the lower end has space for the burner. After fabrication, both sections are mounted on a two wheeled buggy. A two-inch nipple holds up one end so that the assembly will set firmly on uneven ground.

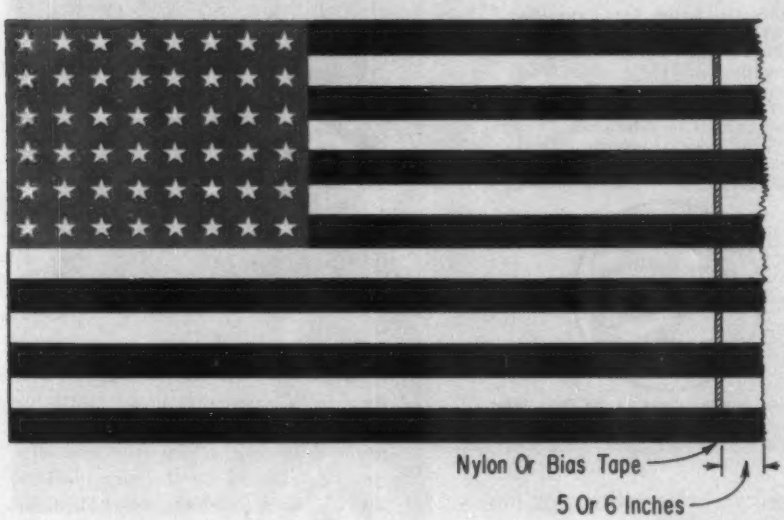
How to Do It...

In operation, the fuel tank is filled about three-fourths full of kerosine or distillate fuel, and about 50 pounds of pressure applied by means of a tire pump. The outlet line, which is connected to the top of the tank, runs to the bottom to effectively drain the tank and then to the firebox of the heater.

The one-half inch fuel line makes a complete loop through the firebox where the fuel is preheated as it is jetted into the burner. Dope can be applied whenever and wherever needed by keeping this unit near the jobsite.

Item submitted by Harry Hess, Houston.

Tape Greatly Lengthens Life of Flag



Frayed flags are not things of beauty and the maintenance problems soar with each windy day.

The life and appearance of a flag may be increased considerably by sewing a small strip of nylon or bias tape near the end of the flag, as shown.

The strip will hardly be noticeable, and the flag life will increase

$$ Your Ideas Are Valuable! $$

At least $10.00 will be paid for each idea accepted for "How To Do It." All you need to do is write a brief note telling about your idea, then attach a photo or sketch (if needed), and mail it to Editor, Petroleum Refiner, P. O. Box 2608, Houston.

Here's proof

Superior quality forged body —precision machined
Uniform wall thickness —no weak spots
Extra heavy reinforcing rim
Larger diameter cam ears for longer service life
Extra Hi-Strength forged handles —greater economy
Stainless Steel pins —greater safety and longer service
Uniform heavy wall thickness —no weak spots
Recess retains gasket in coupler and assures proper placement
Superior quality forged body —precision machined —accurate tolerances

your best buy is EVER-TITE -the best quality quick couplings

Bronze
Aluminum
Stainless
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You save time and money when you use EVER-TITE COUPLINGS, because you get speedy deliveries—no leaks.

The tightness is predetermined in manufacture so you can be *sure* with EVER-TITE.

The EVER-TITE trademark is a hallmark of dependability. EVER-TITES do the best job in the transfer of every type of product through hose or pipe.

Get EVER-TITE and get the *best*. Ask your distributor now.

EVER-TITE COUPLING CO. INC.
254 West 54th Street
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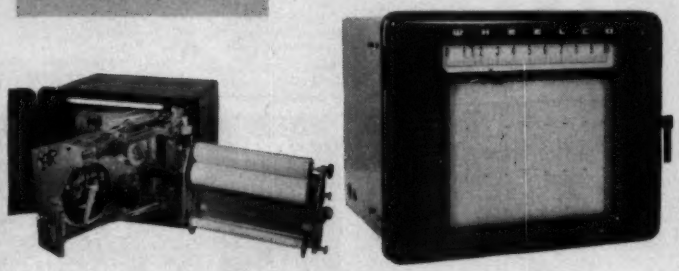
For more data on advertised products, use Readers' Service Cards, last page.

THE MARK OF QUALITY

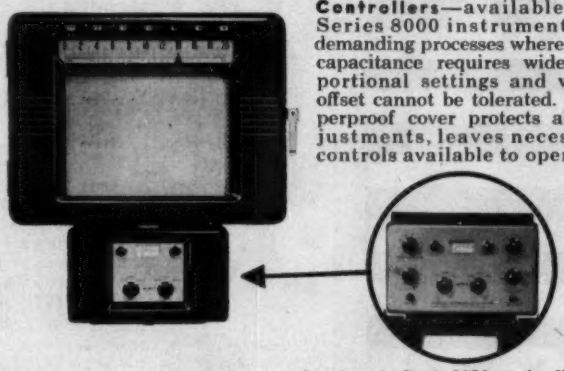
BARBER COLMAN

In recorders and recording controllers ...Wheelco gives you the "extras" that really count

Wheelco Instruments



Series 8000 Recorders and Recording Controllers — available in a wide range of models, these self-contained null-balancing electronic instruments feature convenient swingout design for easy chart and instrument maintenance. Multi-point recorders keep permanent records of up to 16 points on a single chart — feature up to six limit switches for high and/or low signal indications . . . single- or multi-color printing . . . 3 to 24 in. per hr recording speeds.



Automatic Reset for Recording Controllers—available with Series 8000 instruments for demanding processes where small capacitance requires wide proportional settings and where offset cannot be tolerated. Tamperproof cover protects all adjustments, leaves necessary controls available to operator.

See them in Booth 1374 at the Chem Show

Prove in your own plant that more accurate controlling and recording makes a big difference in precision processes. Wheelco Instruments not only provide outstanding operating characteristics but feature easier adjustment, inspection, and maintenance. Get the complete story by calling your nearby Wheelco field engineer or writing today for Bulletin F-7955. Wheelco gives you faster deliveries, too!

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How to Do It . . .

considerably when the raveling is confined to the 5 or 6 inches on the end.

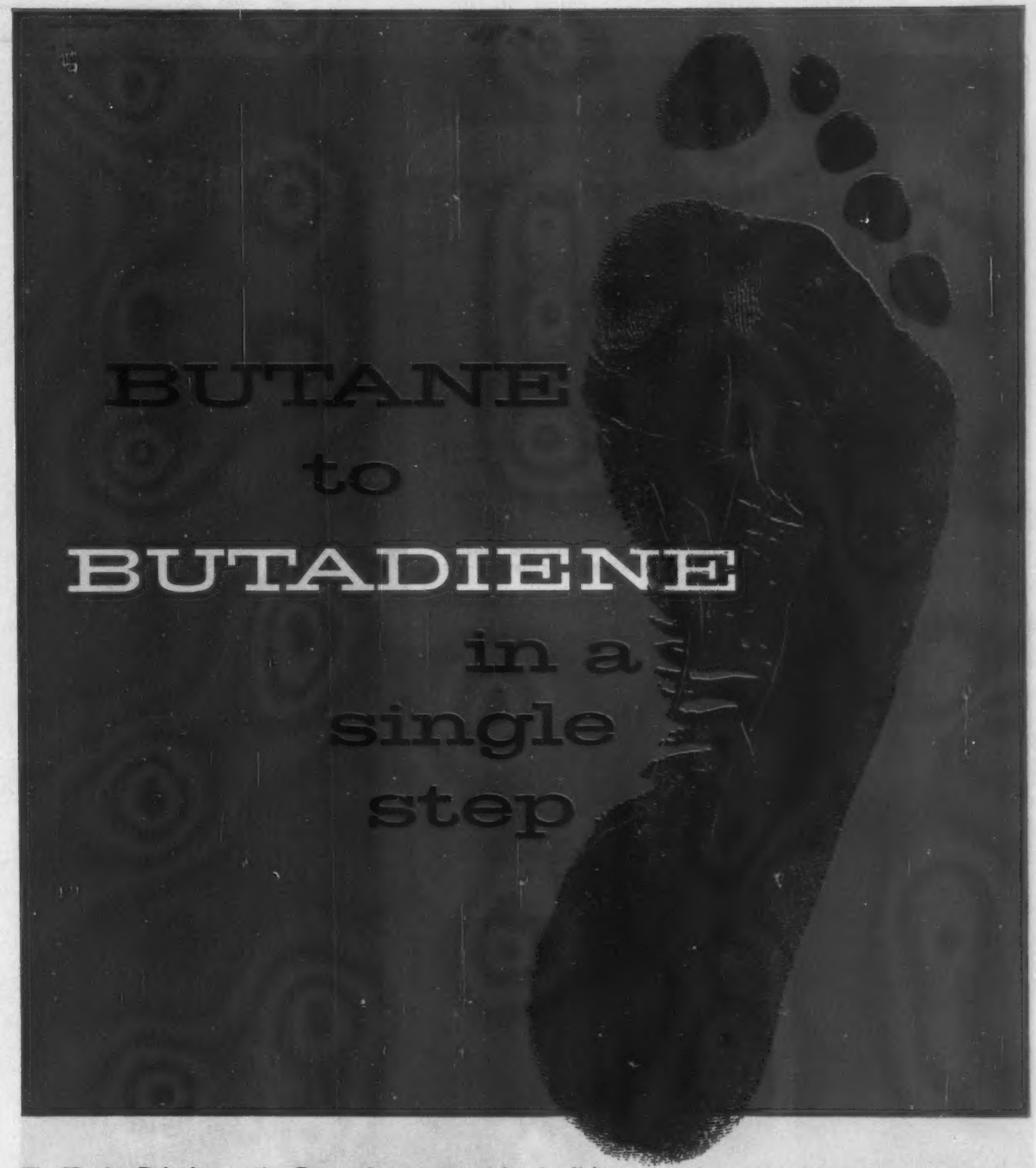
Idea submitted by Chester Sapp Ethyl Corp., Pasadena, Texas.

Clay Holds Thermometer

Where it is desired to note the drop in temperature on unprotected lines or whenever it is necessary to know the temperature of the fluids inside a pipeline, a glass thermometer can be fastened to the pipe (white arrow) with modeling clay usually used in the classroom. This clay has a low coefficient of viscosity change when the temperature is increased and will hold the thermometer in place. Where the thermometer is to be left unattended, a rag can be tied over the modeling clay.

By using a few thermometers and some clay, spot checks may be easily made throughout the plant to get the exact drop in temperature from one vessel to another.

Idea Submitted by: Harry Hess, Houston.



The Houdry Dehydrogenation Process is *unsurpassed* for simplicity and flexibility in transforming through a *one-step process*—

- Butane to Butadiene or Butenes
- Isobutane to Isobutene
- Butenes to Butadiene
- Other light hydrocarbons to mono- and di-olefins

• Since 1955 more than 300,000 annual tons of Houdry butadiene capacity has been licensed. • All new U.S. butadiene plants placed on stream since the major expansion of the synthetic rubber industry started in 1955 have been Houdry-designed and -licensed.

Houdry Dehydrogenation Catalysts are unsurpassed, too, for stability and selectivity in single-step olefin production.

Consult with us—Houdry Dehydrogenation may be profitable for you.

* HOUDRY PROCESSES

*Houdry means Progress . . . through Catalysis

HOUDRY PROCESS CORPORATION, 1528 WALNUT STREET, PHILADELPHIA 2, PA.

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In *critical* processing at SUN OIL... SELAS Gradiation®

SUNOCO

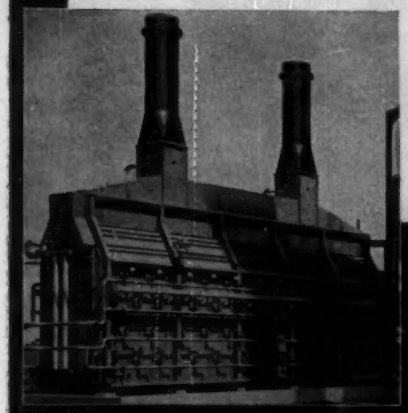
Take catalytic reforming. Rapid, precise heating is of utmost importance in this critical petroleum process. Where a 5°F variation in outlet temperature can adversely affect product octane by as much as one number, the value of Gradiation heating—providing ±1°F control—is obvious.

Selas Gradiation heaters are in service in most of the major catalytic reforming processes: in visbreaking, light hydrocarbon pyrolysis, in high temperature heating including cylindrical reactors.

In critical processing operations in the petroleum and petrochemical industries, Selas Gradiation heating provides

- Preciseness of heating
- Ability to handle a variety of feed stocks; for example: ethane, propane, ethane-propane mixtures including propylene—in one heater
- Instant response to controller demand, achieving close equilibrium approach
- Zone Control . . . up to 3 independent coils in the same heater

Specially-engineered and custom-built to meet your specific processing needs, Gradiation tubular heaters are available both Selas-shop-assembled and field-erected.



Selas multiple-coil Gradiation heater in Houdriformer service, producing high octane gasoline at Sun Oil Company, Ltd., Sarnia, Ontario, refinery.

Send for Bulletin 72 "Gradiation Heating for Petroleum and Chemical Processing."
Selas engineers will be glad to discuss your heat-processing requirements with you.

Gradiation is a registered trade name of Selas Corporation of America.

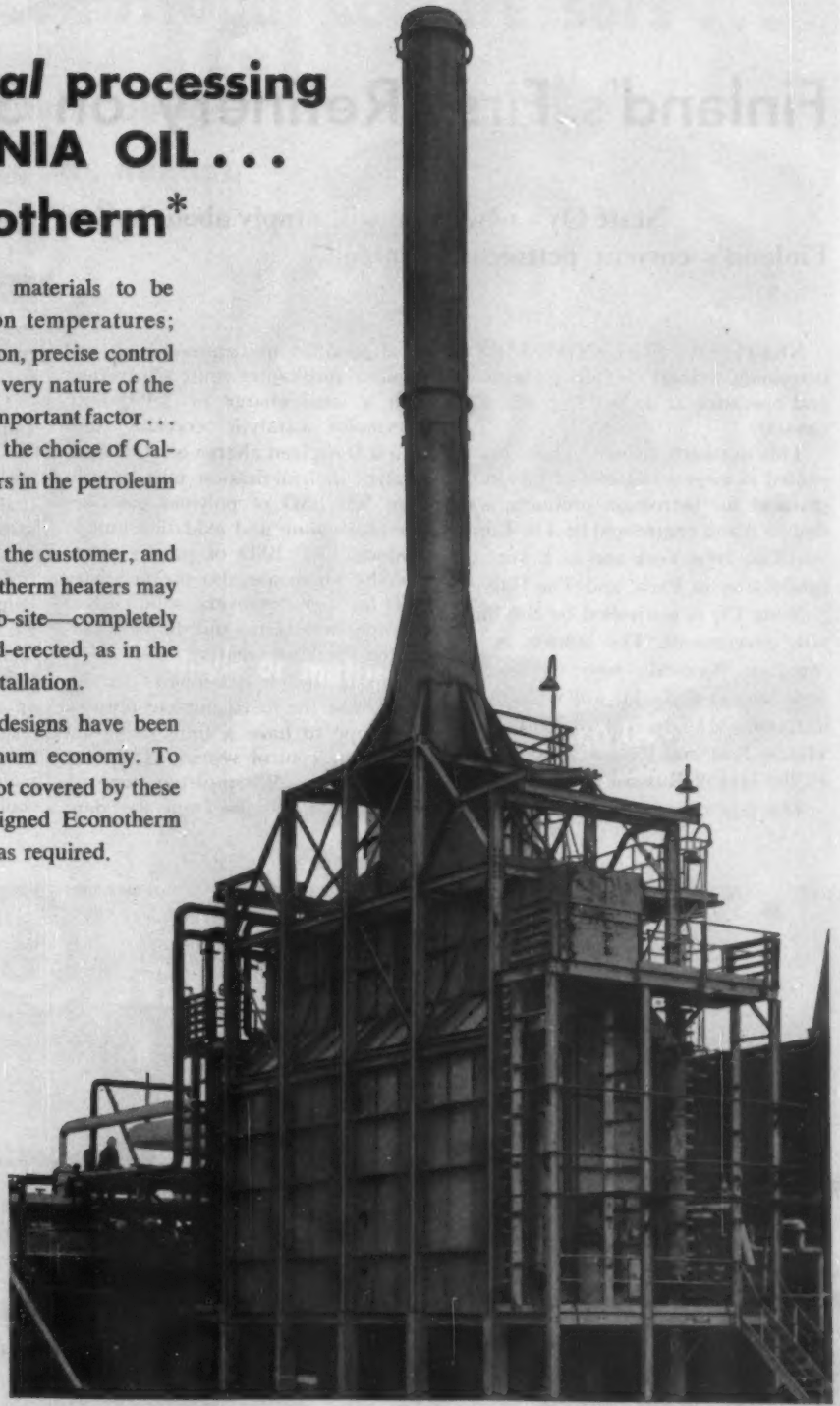
is your reward

In *non-critical* processing at CALIFORNIA OIL . . . SELAS Econotherm*

Where operations require materials to be heated below decomposition temperatures; where, because of this condition, precise control is not required; where, by the very nature of the operation, low first cost is an important factor . . . Selas Econotherm heaters are the choice of California Oil and other processors in the petroleum industry.

Depending on the desire of the customer, and the economy involved, Econotherm heaters may be delivered intact to the job-site—completely Selas-shop-assembled, or field-erected, as in the case of this California Oil installation.

Three basic Econotherm designs have been developed to achieve maximum economy. To meet processing conditions not covered by these standard units, specially-designed Econotherm heaters will be custom-built as required.



Multiple-coil, floor-fired (using combination gas and oil burners) Econotherm crude unit heater in vacuum service at the California Oil Co., Perth Amboy, N. J., refinery.

*Trade Name

SELAS
CORPORATION OF AMERICA
DRESHER, PENNSYLVANIA

Heat and Fluid Processing Engineers
DEVELOPMENT • DESIGN • CONSTRUCTION

For more data on advertised products, use Readers' Service Cards, last page.

Who's Building . . .

Finland's First Refinery on Stream

Neste Oy's new plant will supply about half of Finland's current petroleum demand.

NESTE OY, FINLAND'S FIRST petroleum refinery, is fully on stream, and operating at up to 115 percent of capacity.

This northern refinery which is expected to meet about half of Finland's demand for petroleum products, was designed and engineered by The Lummus Co., New York and its European subsidiaries in Paris, and The Hague.

Neste Oy is controlled by the Finnish government. The refinery is located at Naantali, near the southwestern port of Turku, and is designed to handle a mixture of 18,500 bpd of Middle East and Russian crude oil or 19,200 bpd of Russian crude alone.

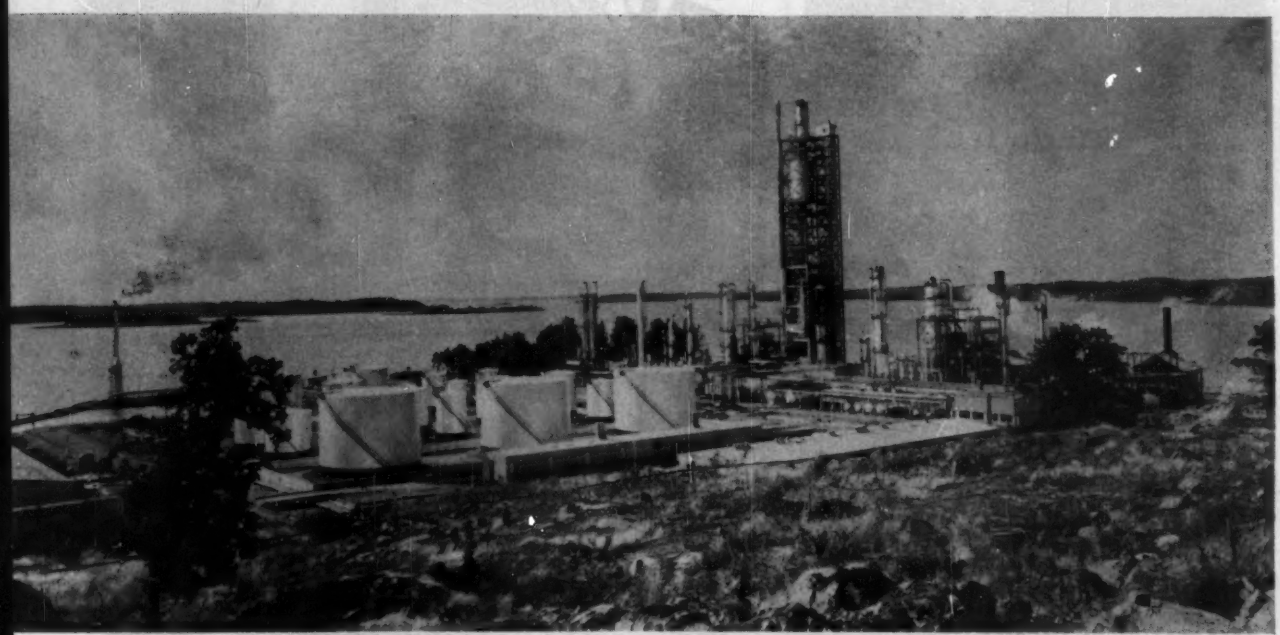
The new refinery includes; an electrical desalting unit; atmospheric and vacuum distillation unit; Catformer, with a total charge of 3,400 bpd; Thermofor catalytic cracking unit with a fresh feed charge of 6000 bpd; catalytic polymerization unit to produce 500 BSD of polymer gasoline; asphalt vacuum and oxidation unit to produce 1300 BSD of paving grade asphalt. There are also the necessary units for vapor recovery, solid copper chloride sweetening and double caustic and inhibitor treating.

One of the few refineries in the world, and the first complete refinery in Europe to have a fully electronic instrument control system, Neste Oy boasts an overall completion time of less than 24 months from the date when procurement areas were first definitely established.

Crude oil was first introduced to the atmospheric unit toward the end of July, 1957. Six weeks after the start-up the refinery was up to capacity, producing a full line of gasoline, fuel oil, LPG, and asphalt products.

Under its contract with Neste Oy, Lummus provided engineering, procurement, coordination, construction supervision and assistance during initial operation. Lummus also provided assistance in arranging for a broad financing scheme, set up an operator training school at the job site, and helped set up the overall refinery organization and manpower requirements.

Since the refinery was constructed on a virgin tract as a grassroots installation, complete auxiliary and offsite facilities had to be provided. These include sea water pumping stations for cooling and fire use, compressor sta-



Reforming and catalytic cracking are included in Finland's new refinery.

ELLIOTT Centrifugal Compressors . . .

for flexibility in design
to meet your specific needs!

MULTISTAGE, TURBINE-DRIVEN . . .

this Elliott centrifugal compressor, rated 135,500 inlet cfm, inlet pressure 14.5 psia, discharge pressure 22.0 psig, is driven by an Elliott turbine rated at 12,440 hp, at 2400 rpm.

SINGLE-STAGE, MOTOR-DRIVEN . . .

this Elliott centrifugal compressor, rated 25,650 inlet cfm, inlet pressure 13.7 psia, discharge 16.7 psia, is driven by an Elliott 500-hp totally-enclosed air-to-air cooled induction motor at 3560 rpm.

For nearly fifty years, Elliott has been building centrifugal compressors for all applications. The standardized conservative design of Elliott compressors results in dependable service and low maintenance.

Manufacturing both turbines and motors which drive the compressors, Elliott is able to match drives to specific compressor requirements both in physical design and in performance.

Call your nearby Elliott District Office for detailed information, or write Elliott Company, Compressor Department, Jeannette, Pa.

P7-4

ELLIOTT Company

For more data on advertised products, use Readers' Service Cards, last page.

tions for instrument and plant air, and outdoor type steam boilers complete with feed water treatment.

Tankage for approximately 30 days storage of crude and finished products, and facilities for railroad, truck and tanker or barge shipment of the products are provided. Also included are facilities for addition and blending of T.E.L., inhibitors, dyes, deactivators, etc. as required for the various distillate products.

Due to its somewhat remote location the refinery has its own firehouse, firefighting equipment, and firefighting force. Also contained are a fairly complete warehouse and workshop, a well equipped laboratory for purposes of plant control and research, as well as an administration building.

The supply of material and erection of Neste Oy was handled by a French group headed by Fives-Lille and the Mannesmann organization in Germany.

British Petroleum Co., Ltd., is planning to build an oil refinery with a capacity of at least 40,000 bpd, on the East bank of the Oslo Fiord in cooperation with its Norwegian subsidiary, Norsk Braendselolje.

Standard Oil Co., (New Jersey) has already announced that its affiliate will build a $30.7 million plant at Oslo. It was also announced by Shell that it is considering building a Scandinavian refinery.

Austrian Oil Administration's projected new refinery at Schwechat will be built in two stages, with a final annual capacity of 2.5 million tons after its final stage is completed sometime in 1962.

Work on the first stage will start December, 1959 and it is expected to cost about $27.2 million. It is expected that the new refinery along with established plants will be able to furnish the country's needs of oil products.

Royal Dutch Shell group may establish an oil refinery in Mombasa, Kenya (East Africa) according to Barclays Bank D.C.O.

The bank quotes the Kenya Minister for Commerce as saying that the group has more than two years in which to make up its mind, but that a decision before then is likely. The group has acquired the land it needs and has carried out certain preliminary investigations.

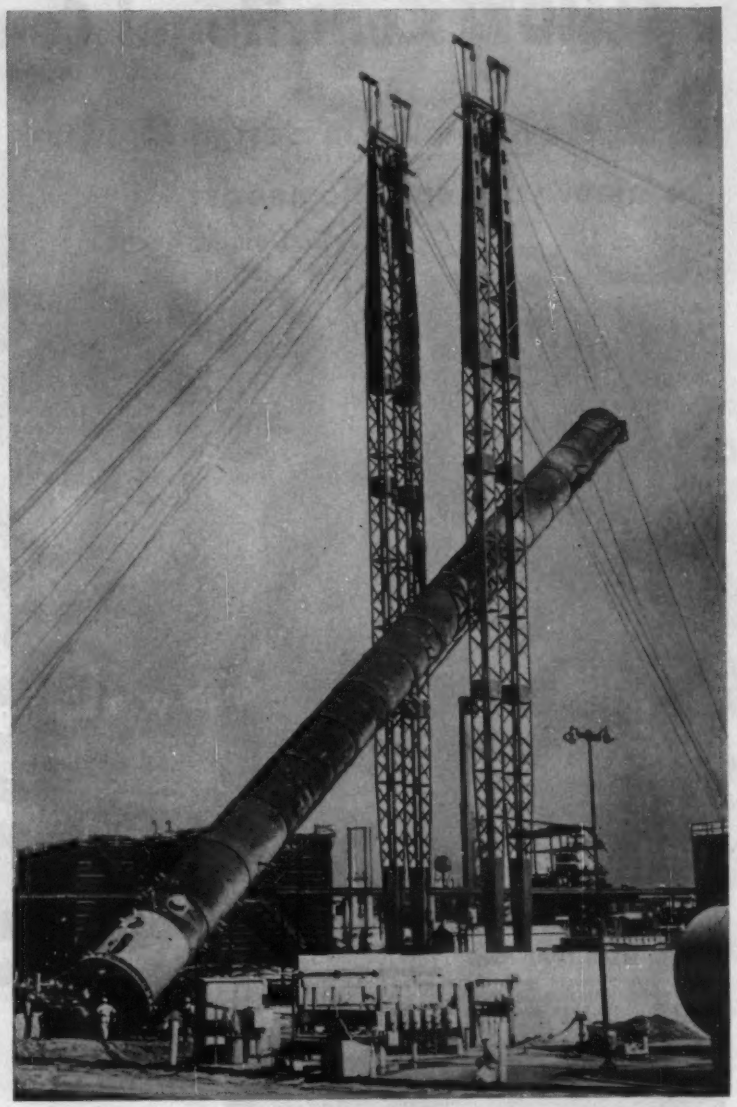
French oil companies are planning to build a 70,000-bpd refinery in Strasburg to supply Eastern France, Southern Germany and Switzerland.

The companies, all but one government owned or controlled, are Compagnie Francaise des Petroles, Cie Francaise de Raffinage, and the Pechelbronn-Antar-Petroles de l'Atlantique group. Pechelbronn is privately owned.

When it is completed, this will be France's first refinery located inland, near the oil markets and far from the coast.

A crude oil pipe line is to be constructed from Marseille to Strasburg. If longer range plans to lay a pipe line network from Marseille to Belgian, Dutch, and German refineries materialize, it would be tied into the Strasburg project. The new plant would also process Algerian oil, which is expected to be flowing in large volumes by 1960 or 1961.

Up She Goes!



A 350-ton deisobutanizer distillation column, 212 feet high, was raised into position in one piece at the El Segundo refinery of Standard Oil Co., of California, Western Operations, Inc. The lift was one of the heaviest ever accomplished in the U. S. with a load of this type. Macco Refinery and Chemical Division, California, was the prime contractor for construction.

Chowguli & Co., (Hind) Private, Ltd., Bombay, India, has been investigating the possibilities of manufacturing phthalic anhydride from naphthalene, but due to the non-availability of naphthalene in quantities for the development of a phthalic anhydride plant, the company is now studying the use of ortho xylene. Production will initially be about 2500 tons per year. Chowguli & Co. is interested in receiving offers for installation of a complete unit together with the technical know-how.

The Texas Co. has completed conversion of a Hydroformer into a UOP Platforming unit at its Lockport, Ill., refinery, and the unit is now on stream.

A Unifining unit, set up in combination with the Platformer at Lockport, serves as a pre-treater. It is processing an intermediate straight run naphtha, derived from Mid-Continent crudes. The Platformer produces a clear high-octane blending component. The combination unit has a design capacity of 9000 bpd.

Another Unifining unit is under con-

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

385 Madison Avenue New York 17, N. Y.

WORLD'S NORTHERNMOST REFINERY ON STREAM

Finland's First Refinery, Engineered by Lummus, Now Fully Operating at up to 115% of Design Capacity

Finland's new Neste Oy refinery, designed to handle a mixture of 18,500 B/D of Middle East and Russian crude oil, or 19,200 B/D of Russian crude alone, is now on stream.

Located at Naantali, near the southwestern port of Turku, the new refinery includes the following units: an electrical desalting unit; atmospheric and vacuum distillation unit; Atlantic Catalytic Reforming Unit (Catformer) with a total charge of 3400 BSD; Socony Mobil Thermofor Catalytic Cracking Unit with a fresh feed charge of 6000 BSD; California Research Corporation Catalytic Polymerization Unit to produce 500 BSD of polymer gasoline; asphalt vacuum and oxidation unit to produce 1300 BSD of paving grade asphalt. There are also the necessary units for vapor recovery, solid copper chloride sweetening and double caustic and inhibitor treating.

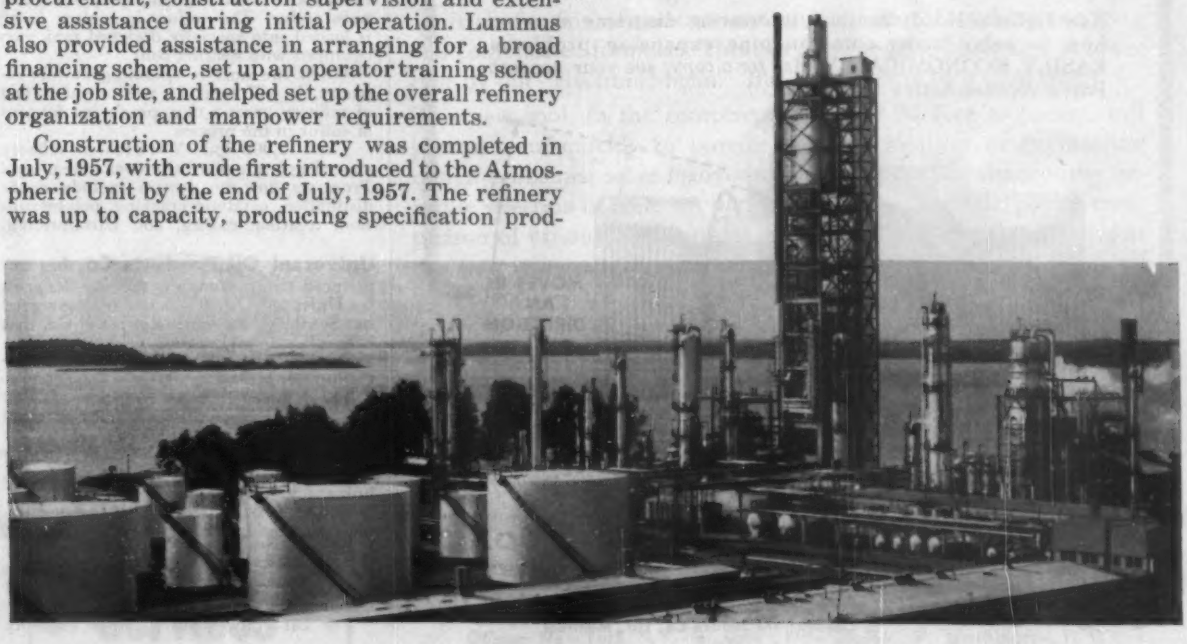
Under its contract with Neste Oy, Lummus provided detailed engineering, coordination of all procurement, construction supervision and extensive assistance during initial operation. Lummus also provided assistance in arranging for a broad financing scheme, set up an operator training school at the job site, and helped set up the overall refinery organization and manpower requirements.

Construction of the refinery was completed in July, 1957, with crude first introduced to the Atmospheric Unit by the end of July, 1957. The refinery was up to capacity, producing specification products within 6 weeks after start-up. Overall completion time was less than 24 months from the date when procurement areas were first definitely established.

One of the few refineries built thus far to have a fully electronic instrument control system, the new installation will meet about half of Finland's demand for petroleum products.

For design, engineering and construction of refineries anywhere in the world, Lummus' over fifty years of world-wide experience is at your disposal.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y., *Engineering and Sales Offices and Subsidiaries:* New York, Houston, Baton Rouge, Montreal, Caracas, London, Paris, The Hague, Bombay. *Sales Offices:* Chicago, Washington, D. C. *Engineering Development Center:* Newark, New Jersey.



EVERY ENGINEER will want a copy of this NEW BULLETIN

BULLETIN No. 31

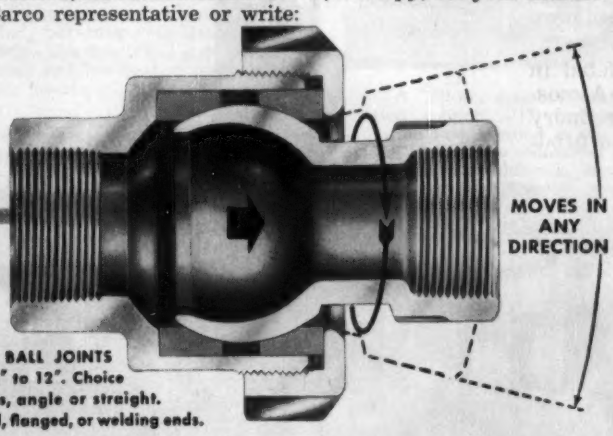
HOW TO SOLVE

PIPE EXPANSION PROBLEMS

CERTAIN distinctive characteristics and features make Barco Flexible Ball Joints particularly well-suited for solving many present-day plant piping design problems, especially for *Steam Service:*

1. Ability to handle compound movement (where twisting is combined with thermal expansion and contraction).
2. Virtually no deterioration. Able to stay in service for years without repairs or maintenance. No lubrication.
3. No heavy pipe anchoring required. No "end thrust" developed under pressure. Minimum space needed for installation.
4. Maximum safety for high temperature applications. All-metal construction available. Special metals can be specified.
5. Basic design is pressure sealing against leakage and self-adjusting for wear. Suitable for steam pressures to 750 psi and higher.
6. Easy to engineer joints into piping to provide for any degree of flexibility, expansion, or movement required.

New Bulletin No. 31 contains interesting diagrams showing how to solve many common pipe expansion problems EASILY, ECONOMICALLY. *Ask for a copy;* see your nearest Barco representative or write:



BARCO BALL JOINTS
Sizes ½" to 12". Choice of styles, angle or straight. Screwed, flanged, or welding ends.

BARCO MANUFACTURING CO.
5420 Hough Street • Barrington, Illinois

PRODUCTS BACKED BY EXPERIENCE
BARCO
ANNIVERSARY 1905 50TH 1955

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints
In Canada: The Holden Co., Ltd., Montreal

Who's Building . . .

struction at the Lockport refinery to serve as a pre-treater for the No. 1 Platformer which has been on stream since August, 1955. The No. 1 unit has a design capacity of 10,000 bpd.

The Pure Oil Co. has announced that a new multi-million dollar catalytic reforming unit has been put into operation at its Lemont, Ill., refinery.

The new unit employs a platinum catalyst in converting low-octane naphtha into a high-octane gasoline stock. Its capacity is 12,000 bpd.

The unit was designed and built for Pure by The M. W. Kellogg Co.

Shell Chemical Corp. will begin building two new plants at Norco, La., early in 1958.

R. C. McCurdy, Shell Chemical president, said one plant will make acrolein and the other will convert some of the acrolein to glycerine "at an original rate of 35 million pounds a year."

Volume production of acrolein was made feasible by Shell Development Company's discovery of the "hydrogen peroxide-acrolein route to glycerine," according to Mr. McCurdy.

A plant for making hydrogen peroxide for the new process has been put on stream, and Shell Chemical is now marketing hydrogen peroxide.

"As glycerine production begins in the new plant, it will be necessary to reduce the volume of glycerine made by the present allyl chloride method. This will release allyl chloride for other allyl chloride derivatives such as epichlorohydrin, epoxy resins and allylamines," he said.

American Oil Co. has placed in operation a gas treating unit to remove sulfur from refinery streams at its Yorktown refinery.

The new unit consists of an absorber system which removes sulfur compounds from refinery gases and recovery equipment which converts these compounds into pure sulfur. The sulfur, in molten form, is loaded into specially designed tank cars equipped with heating coils.

When the unit is operating at full capacity, it will treat 21 million cubic feet of refinery gases a day, producing 50 tons of sulfur in the process.

The 35,000-bpd Yorktown refinery started operations a little over a year ago. Processes now on stream include crude distillation, catalytic cracking, polymerization, treating, coking, and Ultraforming.

Universal Oil Products Co. has announced that a complete refinery designed by Universal Oil Products and engineered by Southwestern Engineering Co. has been placed in operation by El Paso Natural Gas Products Co. at Ciniza, near Gallup, N. M.

The refinery is at an elevation of 7000 feet and has an initial capacity of 8000 barrels of crude per day which can be expanded to 13,000 bpd. Various blended crudes from the San Juan Basin area are brought to the refinery by pipeline.

Major processing units licensed by UOP include fluid catalytic cracking, Platforming and "HF" Alkylation. Other equipment includes crude and vacuum distillation and gas concentration and treating facilities.

The cat cracker has a design capacity

IBM Electronic Computing Equipment solves engineering problems fast in the Data Processing Department at McKee offices in Cleveland.

Electronic Computer speeds McKee engineering of your new plant

THE obvious advantage to you of McKee's IBM 650 Computer is elimination of the time-consuming labor of working out long and complicated formulae. This can now be done faster and at lower cost by our "electronic brain." But there's more to it than that.

This new tool, in the competent hands of McKee engineers, will process data quickly to provide accurate solution of engineering design problems; solve many intricate equations simultaneously; expedite selection of ***economic optimum*** design conditions; permit comparison of various combinations of processes and designs to arrive at the ***most economically attractive*** combination for correct design of your plant.

The 650 Computer will not, of course, replace engineering brains, experience and judgement. We'll continue to use those for constructive thinking—the kind of constructive thinking you'll want in the design and construction of your new plant.

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No embrittlement! Lowest cost! ASME Code approved!

In the subzero operating range . . . Specify Alcoa Aluminum equipment and piping

The flow chart details a tonnage oxygen plant now in actual operation where process temperatures average below minus 300° F. Notice that virtually all of the equipment and process piping are ALCOA® Aluminum. There's a good reason: aluminum is the lowest cost metal able to perform satisfactorily at low temperatures.

At subzero temperatures, ASME code approved aluminum alloys suitable for welded construction display improved yield and tensile strengths with no reduction in ductility or resistance to shock loading (see graphs). There is no embrittlement!

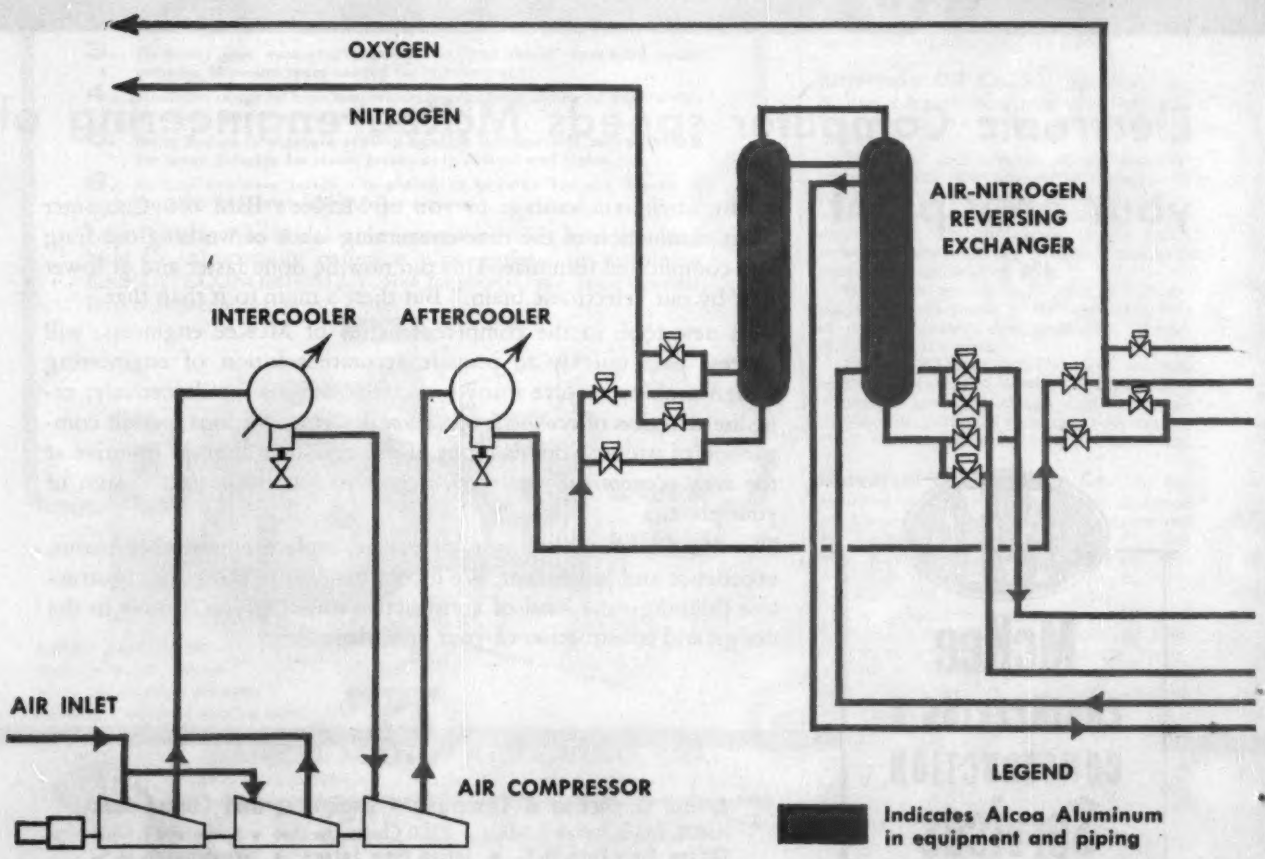
And in these operating temperature ranges, aluminum offers other valuable benefits . . . light weight . . . excellent resistance to corrosion . . . great strength in alloys . . . high thermal conductivity . . . nonmagnetic, nonsparking characteristics . . . nontoxicity . . . and excellent reflectivity. It is highly workable and lends itself readily to a variety of welding or brazing techniques for easy fabrication.

When *you* are looking for a low cost answer to the many problems of satisfactory equipment and piping performance in low temperature operations, *it will pay you to specify Alcoa Aluminum.* ALCOA engineers have worked with aluminum in the process industries for over 30 years. Use their accumulated knowledge to help you find satisfactory answers to *your* process equipment problems. Consult the nearby ALCOA sales office listed in the Yellow Pages of your telephone directory . . . or outline your equipment requirements in a letter to ALUMINUM COMPANY OF AMERICA, 905-B Alcoa Building, Pittsburgh 19, Pa.

NEW!
"ALCOA THEATRE"
Exciting Adventure
ALTERNATE MONDAY EVENINGS

ALCOA ALUMINUM

THIS FREE BOOK is filled with detailed data on the behavior of aluminum in the process industries . . . the result of more than 30 years of Alcoa engineering experience with aluminum in a variety of applications in nearly every temperature range. Use it as your guide to trouble-free, corrosion-free process equipment and piping. Write today for *Process Industries Applications of Alcoa Aluminum.*



For more data on advertised products, use Readers' Service Cards, last page.

LOW TEMPERATURE PROPERTIES OF ALCOA ALLOY 5154-0

Alcoa Aluminum actually increases in strength with no loss in ductility as temperatures drop to minus 320°F and below. Alloy 5154-0, for example, improves 50% in tensile strength, over 13% in yield strength and approximately 60% in elongation.

Photograph shows installation of Alcoa Aluminum equipment and piping in oxygen plant detailed in flow diagram. Harp-type heat exchangers (left) are dip-brazed assemblies with thousands of fins for best heat transfer.

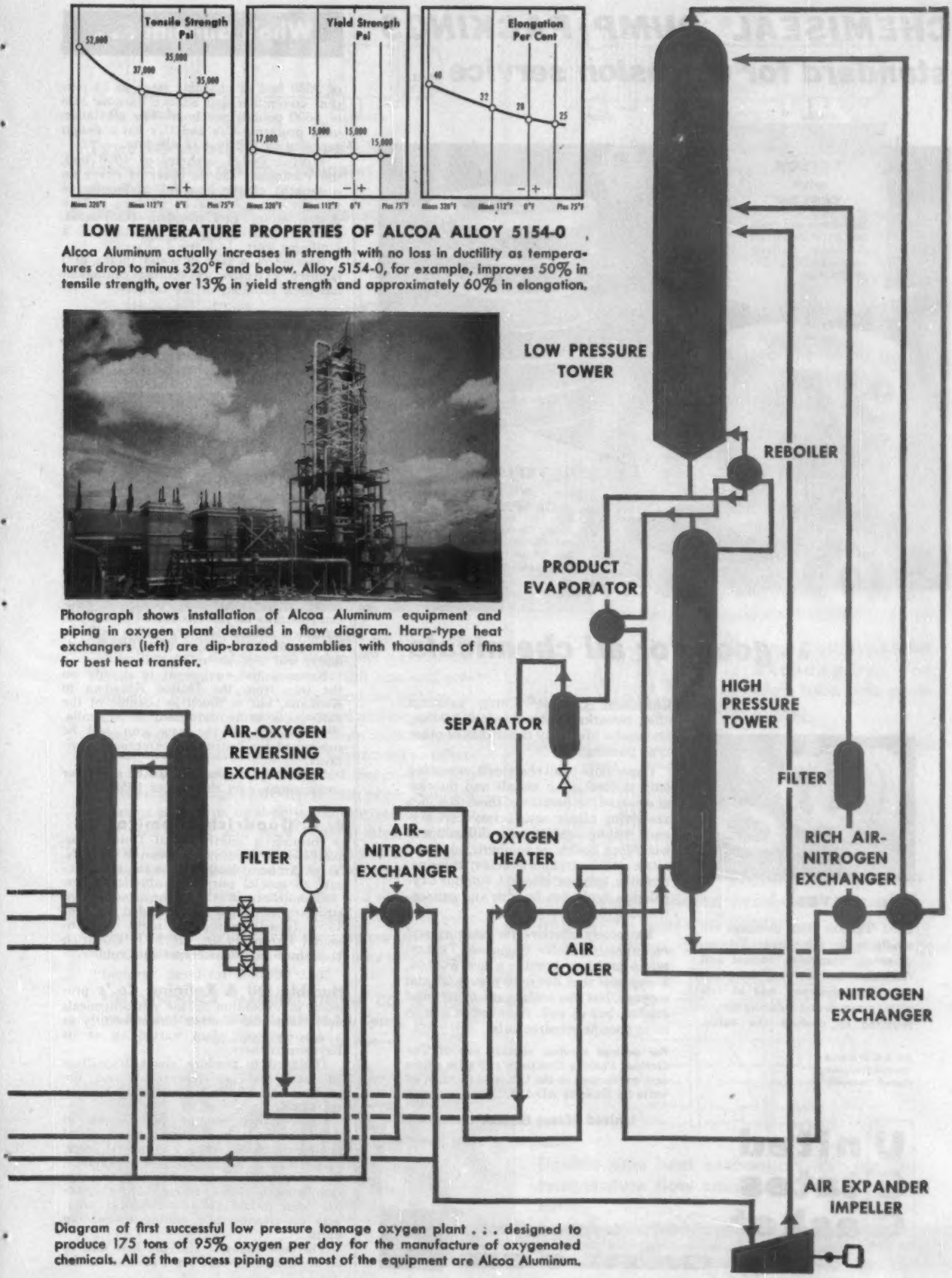
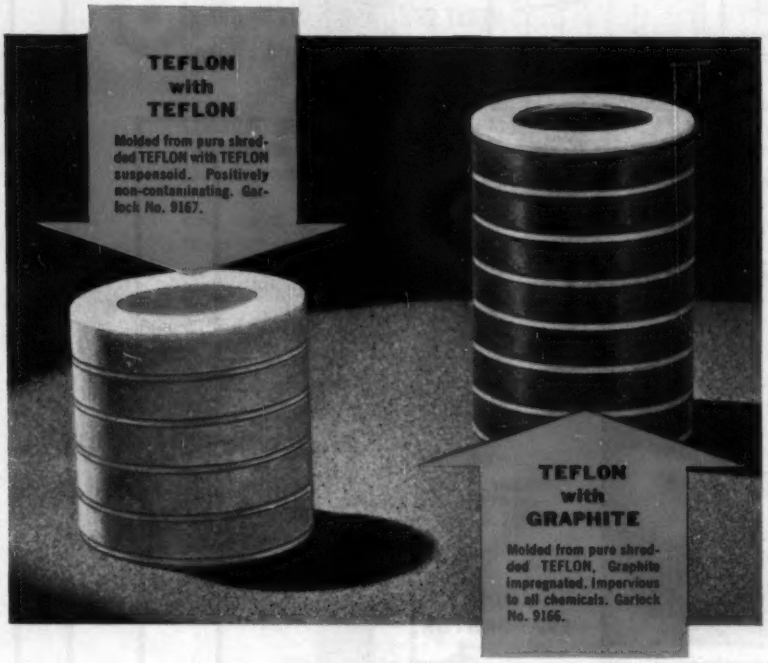


Diagram of first successful low pressure tonnage oxygen plant . . . designed to produce 175 tons of 95% oxygen per day for the manufacture of oxygenated chemicals. All of the process piping and most of the equipment are Alcoa Aluminum.

For more data on advertised products, use Readers' Service Cards, last page.

CHEMISEAL® PUMP PACKINGS
standard for corrosion service . .


TEFLON
with
TEFLON
Molded from pure shredded TEFLON with TEFLON suspensoid. Positively non-contaminating. Garlock No. 9167.
TEFLON
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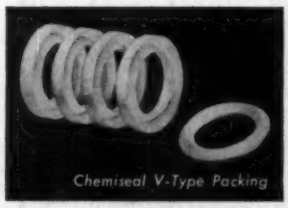
GRAPHITE
Molded from pure shredded TEFLON, Graphite impregnated. Impervious to all chemicals. Garlock No. 9166.

. . good for all chemicals



FOR VALVES

Solid TEFLON Ring packings are available in Chemiseal V-type, diagonal, triangular, conical and Garlock Chevron ring designs—providing necessary seal at low gland pressure and reducing torque required to operate the valve.

Chemiseal TEFLON* Pump packings offer remarkably trouble-free service, and useful life many times that of other type packings.

Impervious to all chemicals, excepting only molten alkali metals and fluorine at elevated temperatures, these packings are giving highly satisfactory performance sealing against such difficult and hazardous liquids as sulphuric, chromic, nitric and hydrofluoric acids; chlorine, bromine, sulphur chloride, sulphur oxychloride, hydrogen fluoride and concentrated hydrogen peroxide.

Extremely effective for rotating and reciprocating shafts, Chemiseal TEFLON pump packings provide a low friction, 2-way seal that not only prevents axial seepage, but also seals against shaft and stuffing box as well. Supplied in sets to meet specific requirements.

For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses in the U.S. and Canada, or write for Bulletin AD-155.

United States Gasket Company
Camden 1, New Jersey

®U.S.G. Trademark
*du Pont Trademark
†Garlock Trademark

United States Gasket Plastics Division of GARLOCK

Who's Building . . .

of 3380 bpd of charging stock at 75 percent conversion and a coke burning rate of 4600 pounds per hour. The alkylation unit, procesing C_3's and C_4's has a design capacity of 750 bpd of alkylate.

With a design capacity of 4500 bpd, the Platformer can be operated either on a naphtha charge or a full boiling range straight run gasoline to produce a high octane motor fuel blending component. Future plans call for installation of a Unifining unit.

Because of a lack of water in the arid country, extensive air cooling equipment has been installed in the refinery.

Yacimientos Petroliferos Fiscales (YPF) is making plans to expand the Lujan de Cuyo Refinery in Mendoza, Argentina, from 11,900 barrels daily capacity to 40,000. A catalytic cracking unit, naphtha reforming facilities, and possible other units will be involved. The expansion project was expected to begin in 1958 and to be completed in 1960.

Jordan has plans for a new refinery. The location would be near Zerks, and capacity would be about 7500 bpd when completed. Trans-Arabian Pipe Line Co. would supply crude oil for the refinery.

British Petroleum Co., Ltd., has announced that work is to start next month at B.P.'s Kwinana refinery in Western Australia on the erection of a catalytic reformer. The reformer, which will be capable of a throughput of 10,000 barrels daily, will cost about $8 million.

Some of the equipment is already on the way from the United Kingdom to Kwinana, but as much as possible of the material is being purchased in Australia. The erection of the new unit will be supervised by British and American engineers.

The catalytic reformer will be ready for commissioning by the end of 1958.

B. F. Goodrich Chemical Co. is forming a jointly-owned Dutch company with Algemene Kunstzijde Unie N. V. of Arnhem, Holland, for the manufacture of special purpose synthetic rubber.

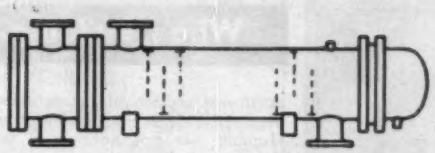
Completion of the plant, to be constructed at Arnhem, is scheduled for mid-1959. It will be the first plant in continental Europe to use the B. F. Goodrich know-how to produce synthetic rubber.

Humble Oil & Refining Co.'s program of expansion in the petrochemicals field completed another phase recently as a new benzene plant started up at its Baytown refinery.

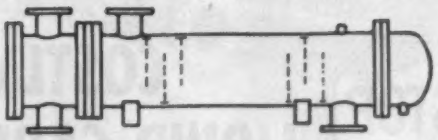
Designed to produce about 30 million gallons of high purity benzene a year, the plant is one of the largest of its kind in the world.

Construction on the unit began in April, 1957. It is the first petrochemical plant built at the refinery in several years. The last unit, which produces paraxylene, the base stock for synthetic fibers, was completed in 1953. Since then, Humble has been producing new chemical products by altering and adding to existing units.

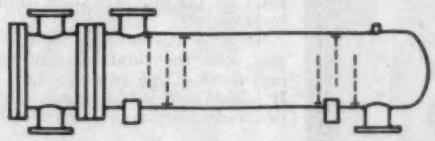
The new plant is also the first unit to be built on a 40-acre tract of land in the



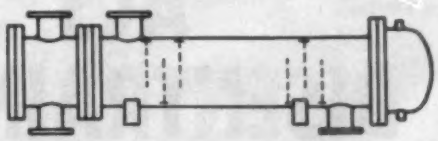
Type SG straight tube, outside packed lantern gland design. Eliminates undetected fluid inter-leakage.



Type S pull-through floating head design. For condensing, heating services . . . easy maintenance.

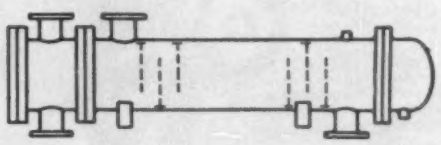


Type R U-tube design. Low cost construction, for non-fouling service.



Type ST conventional straight tube, split ring, floating assembly construction.

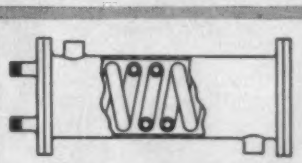
Standardized Heat Exchangers cut your costs!



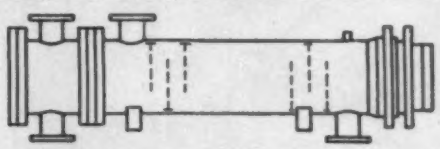
Straight tube, fixed tube sheet design. Types V and V-1—for easy mechanical cleaning.

Again and again through the years we have been called upon by customers to design and manufacture Heat Exchangers of almost identical size and construction. Now, we have standardized the building of some units most commonly ordered and can produce these quickly and economically from stock material. There are of course many other advantages to selecting Heat Exchangers of standard design, including substantial savings in their purchase price. Standard designs permit us to supply accurate prints quickly for your piping and other layouts. Also, duplicate parts can be supplied promptly if you need emergency repairs, greatly reducing downtime.

Our engineers will gladly assist you in selecting a standard Whitlock Heat Exchanger suited to your requirements. Write us and compare our prices with those of comparable equipment by any other manufacturer. Send for Bulletin 250.

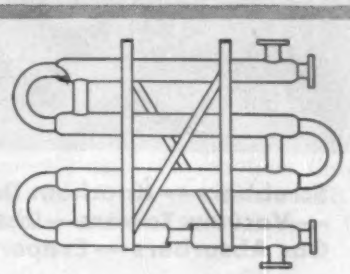


Type C coil type heat exchangers. For high tube side pressures.



Floating head heat exchangers. Type SO with outside packed head—no concealed, bolted and gasketed joints.

THE WHITLOCK MANUFACTURING CO.
75 South Street, West Hartford 10, Conn.
In Canada: Darling Bros., Ltd., Montreal



Double pipe heat exchangers. For counter-temperature flow conditions and low flow rates.

Whitlock

Designers and builders of bends, coils, condensers, coolers, heat exchangers, heaters, piping, pressure vessels, receivers, reboilers.

COSTLY LIQUID CARRY OVER with "ACS" DISENTRAINERS

(MESH ENTRAINMENT SEPARATORS)

"ACS" Disentrainer Installed Here
Photograph Courtesy of SINCLAIR REFINERY'S New Unit At Corpus Christi, Tex.
Fabricated By DELTA TANK BATON ROUGE, LA.

USED IN: **Scrubbers — Knockout Drums — Steam Drums — Vacuum Towers — Distillation Equipment — Gas Absorbers — Evaporators.**

Let our experienced engineers help you with your separation problems. Size, type and best metals for your specific use will be recommended. All inquiries receive prompt answers. Write for our 16-page Catalog.

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ACS DISENTRAINER DIVISION

American Copper Sponge Company, Inc., 189 Charles St., Providence, Rhode Island

Who's Building . . .

northwest section of the refinery that has been set aside as a specialty products area. Humble has not announced what additional petrochemical units will be built in that area and an adjacent 40-acre tract also set aside for petrochemical expansion, but the company has indicated that others are planned.

The new facilities are integrated with other refinery operations, and the feed stock for the unit will come from a nearby hydroformer.

Most of the benzene used in the area goes into the production of styrene, an ingredient of one type of synthetic rubber. It is also used in the manufacture of plastics, resins, detergents and insecticides.

The Ohio Oil Co. has announced construction which will complete the initial building program for its Research Center at Littleton, Colo. Construction will begin in March.

In announcing the construction, Dr. W. J. Yost, Research Center director, said that two new wings will be aded to the present building, increasing the area 60 percent to some 70,000 square feet. This addition will increase the working space for the scientific research staff from the present 14,900 square feet to 35,100 square feet, or an enlargement of 135 percent.

Ben Franklin Refining Co. has completed a 1000-barrel HF alkylation unit at its 12,000-barrel Ardmore, Okla., refinery. The Tulsa company fabricated several vessels in its own shops and made the control room large enough to accommodate additional control boards for later expansion. The Refinery Engineering Co., of Tulsa, designed, engineered and installed the alkylation unit.

British American Oil Co., Ltd., has announced that the new 5400 bpd catalytic reformer is now on stream at its Edmonton, Alberta, Canada, refinery.

Constructed at a cost of about $2 million, it will be used in the production of high octane gasoline.

The new unit employs a platinum catalyst process and makes the fourth cat reformer in B-A's continuing program of producing top-quality fuels. It was built by The Lummus Co. of Canada, Ltd., under license from The Atlantic Refining Co.

B-A's Edmonton refinery was opened in 1951. Its present crude processing capacity is 8500 barrels daily.

British American Oil Co., Ltd's., refinery expansion program during 1957 brought the five-year total to over $54 million. Major projects in 1957 included the completion of a catalytic reforming unit and additional crude facilities at Clarkson and a new reformer at Edmonton. B-A's present total refining capacity is 142,000 barrels daily. A sixth refinery is presently underway at Port Moody, near Vancouver, B. C., and a new cat reformer, the company's sixth, was recently announced for Moose Jaw refinery.

A major phase of British American's current expansion program was completed at Clarkson refinery in September, where additional crude processing facilities costing approximately $5.5 million added 40,-

For more data on advertised products, use Readers' Service Cards, last page.

"Bimetal Freeze-up" Can Be More Serious Than Dial Fogging Problem

The first sign of moisture in a dial thermometer usually shows up as condensation inside the dial glass. You are probably familiar with this dial fogging problem which causes difficult reading and the eventual corrosion of the bimetallic element. You may not, however, be familiar with another and actually more serious moisture problem —bimetal "freeze-up."

Both dial fogging and bimetal freeze-up are permanently prevented by RMC's dry air hermetic sealing process.

If moisture is sealed in, or enters a thermometer dial it will find its way to the bimetal element. Then at extreme low temperatures this moisture freezes on the element and bearing surfaces, and the bimetal element will not function should the temperature go lower. Therefore, the operator of the equipment would never know that the temperature had gone below the last indication when the element became frozen.

Here's what makes such a condition hard to spot. The thermometer would operate properly again after a temperature rise of perhaps 20°, and would continue accurate indication even though the fluid dropped again to an even lower temperature than before. However, after it remained at the new low for a few hours, it would again freeze up. Then, as before, any further drop in temperature would not be indicated.

Only a dry-air hermetic seal, as used by RMC, can prevent both dial fogging and bimetal freeze-up. RMC even goes a step further by providing for recalibration at any time without breaking the air-tight seal. An external dial reset screw—exclusive with RMC—permits recalibration without opening the instrument in any way.

Industrial Needs Call For Magnetic Liquid Level Gauge

Magnetic drive provides accurate readings with complete safety in all types of liquids under pressure. RMC Magnetic Level Gauges meet requirements of the Underwriters' Laboratories and A.S.M.E. Boiler Code.

Write, wire or phone—tell us your requirements for indicating instruments, and let RMC engineering skill provide the answers. Rochester Mfg. Co., 38 Rockwood St., Rochester 10, N. Y.

These RMC thermometers have just been submerged in water for 15 minutes—the first of a series of severe tests given RMC thermometers to make sure hermetic seal is perfect.

We make certain that moisture will never bother your RMC thermometer

The RMC hermetic sealing process makes absolutely certain that humid air will not be sealed in the instrument and locks all moisture out permanently. Each thermometer then goes through a series of severe tests. Only those with perfect sealing are accepted for delivery. When you order from RMC you get the *only* industrial thermometer that can *never* be affected by internal dial fogging or bimetal freeze-up.

RMC

ROCHESTER MANUFACTURING CO., INC.
38 ROCKWOOD STREET • ROCHESTER 10, N.Y.

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

REPRESENTATIVES IN ALL PRINCIPAL CITIES

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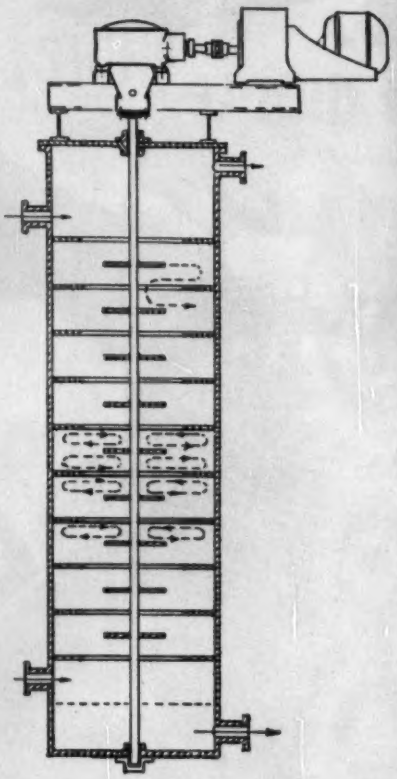
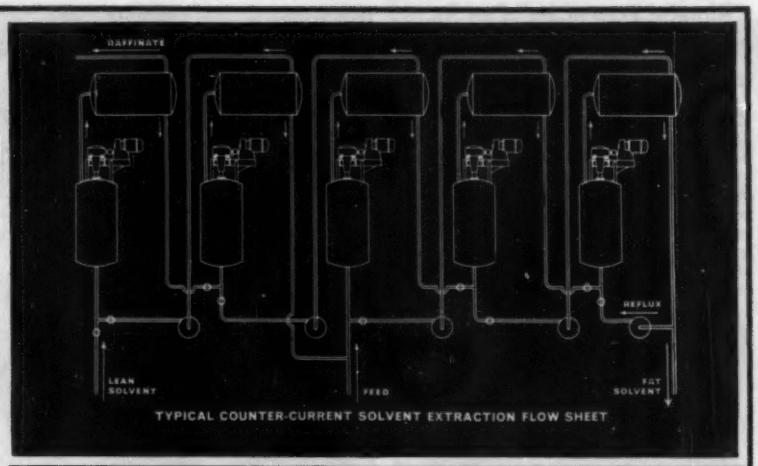


TURBO-MIXER R.D.C. COLUMN
Licensed Under
Shell Development Company Patent



TYPICAL COUNTER-CURRENT SOLVENT EXTRACTION FLOW SHEET

call on TURBO-MIXER for SOLVENT EXTRACTION

Whether you are extracting uranium with mixer settlers (like Kerr-McGee and Vitro) or butadiene (like Esso Standard or Polymer Corporation) or a continuous counter-current extraction column (like Bakelite), there's a Turbo-Mixer designed exactly to meet your needs.

Turbo-Mixers are designed for maximum service, based on over 40 years of experience and specialization in mixer construction. For descriptive information showing how your problems may be solved by Turbo-Mixer, write today.

FOR DETAILED INFORMATION AND USEFUL DESIGN DATA, SEND FOR THE FOLLOWING BULLETINS:

Please send me the following Turbo-Mixer Bulletin (s):

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Who's Building...

000 bpd to the refinery's previous capacity of 21,500 bpd. This expansion was necessitated by the increased demand for all types of petroleum products in the Ontario market. Completion of the expansion coincided with the extension of the Interprovincial Pipe Line from Sarnia to Clarkson.

In addition to the crude facilities, a $4 million catalytic reforming unit was placed on stream at Clarkson at mid-year. At Edmonton refinery, a 5400 bpd cat reformer, costing approximately $3 million.

Another important development in B-A's manufacturing expansion program is the new $25 million refinery under construction at Port Moody, near Vancouver, B. C. With a daily capacity of 20,000 barrels, the refinery will serve the growing Vancouver and west coast markets.

Scheduled for completion late in 1958, the refinery will be located on a 400-acre site adjacent to B-A's Burnaby marketing depot. Just this month a new $4 million catalytic reforming unit was announced for the company's 15,000 bpd Moose Jaw refinery, with completion scheduled for late 1958.

Shell Refining and Marketing Co., Ltd., is erecting a multi-million dollar Udex unit—the first to be erected in the United Kingdom at its Stanlow, England refinery. The unit is expected to be in operation by mid-1958.

Designed and licensed by Universal Oil Products Co., Des Plaines, Ill., the Udex unit will produce an important aviation gasoline blending component. The plant will use as feed stock the products from an existing UOP Platforming unit.

The Udex unit, when completed, will have six columns, the tallest being the solvent stripper which will be 120 feet in height. The extraction column will rise 77 feet.

A special solvent mixture will be used in the unit. Feedstock from the Platformer will be extracted with this solvent mixture which preferentially dissolves the aromatic components of the feed stock. The aromatic extract will be distilled off from the solvent and will be used in aviation gasoline, while the raffinate will be used as an additional feedstock for other processes.

W. R. Grace and Co., New York, plans to build a $15.5 million fertilizer plant in Port of Spain, Trinidad, with construction to run 15 months, beginning in March.

The plant will produce fertilizer from natural gasses and will be called Fertilizer Chemicals, Ltd.

Scientific Design Co., Inc., New York City, has been awarded a contract to design a cumene manufacturing plant for British Hydrocarbon Chemicals, Ltd. The process, originally developed by SD, has been licensed to the British company by Mid-Century Corp., a subsidiary of Standard Oil Co. (Indiana), which acquired exclusive rights to the process last year.

The plant will be built at Grangemouth, Scotland, and will be designed to produce high-purity cumene, which will be used in the manufacture of phenol at the same

for pumping

ECONOMY

you need

MOTORPUMP quality

Here's the major point to keep in mind the next time you're ready to order centrifugal pumps . . . year after year the quality of I-R Motorpumps continues to pay off in actual savings through reduced maintenance costs, uninterrupted service and maximum pumping efficiency.

You can always choose the right pump from the wide range of Ingersoll-Rand Motorpump types and sizes, and be sure of modern design features that assure rugged dependability.

Complete information on I-R Motorpumps is available from your nearby Ingersoll-Rand branch office. Or write for latest bulletin.

MOTORPUMP by Ingersoll-Rand

11 Broadway, New York 4, N.Y.

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PRESSURE CONTROLS

FOR SPECIAL APPLICATIONS

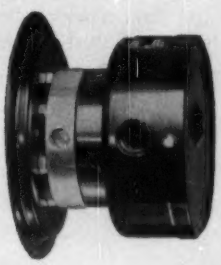
Low Operating Pressure—High Over-Range Protection

- **EXAMPLE APPLICATIONS**

1. Provide low suction protection on pumps where suction pressure may go to very high line pressures (up to 2,500 psi.)
2. As an interlock to prevent a door to a pressure chamber from being opened until the pressure has dropped to atmospheric pressure (1" H2°) with over-range protection to 600 psi.

- **TWO SERIES AVAILABLE**

Series DA-900: Bourdon tube operated. Over-range protection to 2,500 psi. Operating ranges 0-60 psi; 0-100 psi; 0-150 psi; 0-300 psi.



Series CP: Diaphragm operated. Over-range protection to 600 psi. Operating ranges 1"-60" pressure or 1"-60" vacuum.

Both types available in various style cases

SEND IN YOUR CONTROL PROBLEM OR WRITE FOR BULLETINS CA-21 & CA-1P

THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill.

Who's Building . . .

location. It is scheduled to go on stream about the middle of 1959.

British Hydrocarbon Chemicals Ltd., which is jointly owned by British Petroleum Company and Distillers Co., Ltd., operates a large petrochemical complex at Grangemouth.

This will be the third cumene plant engineered by SD.

Canadian Bechtel Ltd. has been awarded contract for construction of processing units in Imperial Oil Co.'s $17 million expansion project at its Calgary refinery.

Construction will start in the spring. It is scheduled for completion in the fall of 1959.

The new facilities will boost processing potential by 80 percent to 14,700 barrels daily.

Sicilian government has authorized construction of 52,000-bpd refinery on Sicily's northeast coast near Milazzo by Societe "Mediterranea" Raffineria Siciliana Petroli. Refinery will be mainly export plant, processing Middle East crude. Port facilities are planned for discharge of tankers.

Italy's interministerial committee for oil industry control has recommended temporary shelving of requests for construction and expansion of refinery capacity in Italy. Possibility of closer coordination between Italian and Sicilian oil industry policies also was mentioned by committee.

Imperial Oil Co., Ltd., Canadian Southern Oil, Ltd., Hudson's Bay Oil & Gas Co., and Consumers' Co-op Refineries, Ltd., have built a processing plant to utilize gas previously flared in the Smiley area of Saskatchewan. The plant is producing 3 million cubic feet of gas and about 60 barrels of gasoline daily.

The plant cost $750,000. It is being operated by Imperial Oil.

The gas produced is going to the Saskatchewan Power Corp. and the gasoline to Mid Saskatchewan Pipe Line, Ltd.

Ohio Oil Co. is adding two wings to its relatively new research center in Littleton, Colo. It will increase space for the scientific research staff 135 percent.

Additions will include laboratories of a more specialized nature than present labs. Construction is to be completed early in 1959.

Heyden Newport Chemical Corp. has opened an automated continuous-production pentaerythritol plant at Fords, N. J.

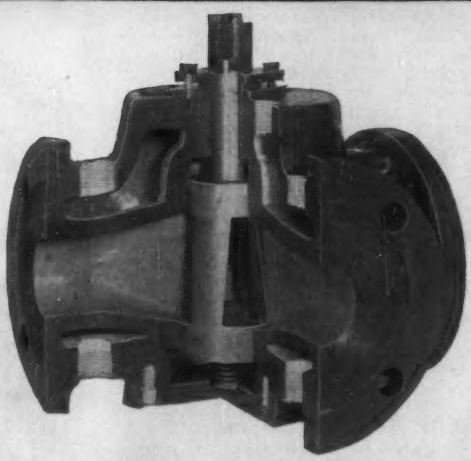
The newest plant can produce 25 million pounds of the industrial chemical annually when operating at full capacity. The plant is part of a major expansion program involving capital expenditures of approximately $25 million in the past five years.

The new plant building, a two and four-story brick and concrete structure, is part of Heyden Newport's Fords works, where formaldehyde and other organic chemicals are produced.

H&B ESTABLISHED 1887

Jacketed Spring Loaded PLUG VALVES

- **2-WAY OR STRAIGHT SPRING LOADED**
- **3-WAY SPRING LOADED**
- **ANGLE SPRING LOADED**
- **AIR CYLINDER OPERATED SPRING LOADED—*all sizes and types***



LONG ON SERVICE . . . SHORT ON MAINTENANCE

H & B's new fully jacketed spring loaded plug valves feature an inverted tapered plug inserted and lapped into the housing from the bottom of the valve—then spring loaded. The spring wedges the plug to a perfectly tight seal, eliminating troublesome leaks. Easy to operate—no big handwheel . . . no freeze . . . no "breaking loose" necessary. Easy to clean. Made in two port or multi port design, with any special stop arrangement desired.

Bulletin J-57 sent on request

HETHERINGTON & BERNER INC., 747 Kentucky Ave., Indianapolis 7, Ind.

For piping systems that can't be anchored, use ZALLEA

HINGED EXPANSION JOINTS

Piping systems like the one in this 63,750 bbl/day catalytic cracking unit, one of the world's largest, at Gulf Oil Corp. Girard Point Refinery, have to be entirely self supporting. The entire cracking unit . . . reactor, regenerator and all connecting lines . . . is suspended in a huge structural steel framework, counterweighted to keep the system in balance, and fitted with Zallea Hinged Expansion Joints to provide vital flexibility plus support for the reactor.

In the 150 ft. air supply line, all thermal movement of the piping is absorbed by angular displacement in three 42" dia. Zallea Hinged Expansion Joints. Start-up air in this line is at 1000°F. Under operating conditions it is delivered at 250°F, 25 psig.

Two 50" dia. Zallea Hinged Expansion Joints in the spent catalyst line carry fluidized cracking catalyst at 950°F, 13 psig.

Since this cracking unit first went on stream, these Zallea Expansion Joints have given completely trouble-free service.

Process piping of any kind can be fully protected with one or more Zallea Expansion Joints. From the complete Zallea line you can select the expansion joint or combination of expansion joints best suited to your particular problems.

Get the complete story in our new 72-page manual. Write today, on your company letterhead, for your copy of Catalog 56. Zallea Brothers, 890 Locust Street, Wilmington 99, Delaware.

Zallea expansion joints

Zallea Brothers • Wilmington 99, Delaware

World's largest manufacturers of expansion joints

NATURAL GASOLINE Plus

QUALITY

QUANTITY

SERVICE

Whatever the grade . . .

Whatever the volume . . .

You can rely on WARREN'S versatile facilities to give you dependable deliveries WHEN and WHERE and the WAY you want them!

"IT'S THE Plus THAT MAKES THE DIFFERENCE"

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As Management Sees It

The Elusive Art of Thinking

Here are the most common executive think "killers", plus some think "stimulators" that will test your reasoning power to the limit.

THINK. Throughout America that word, displayed in large letters on a mahogany board, can be seen gracing the office walls of countless industries. The originator of this motto, in his most prophetic moments, could not have foreseen the wholesale disregard of his admonition.

At least one expert on mental gymnastics has said, "Five percent of the population thinks; 5 percent think they think; and 90 percent had rather die than think."

By the same token, there is evidence in industrial discussion of a growing concern within management over the problem of motivating junior and senior executives to THINK. Many members of top management have expressed certain misgivings over the fact that while the everyday decisions and reports made by their executives are admirable in content and organization, the majority are evidently playing it safe; they seem reluctant to think.

Beware These Think "Killers." The question arises: is this group capable of thinking or has its initiative been suppressed by rejection of former "thinking" solutions to everyday problems? In many cases it is suspected that the latter is true.

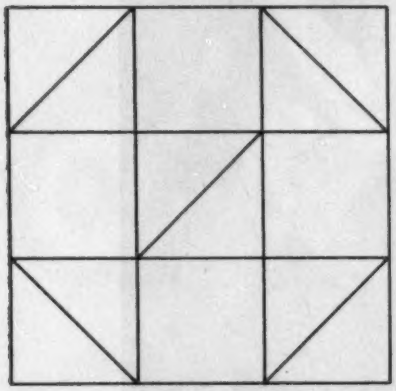
Has the excitement of executive decision-making given way, due to rejection and pressure to conform, to a routine carrying out of assignments? Has the executive been encouraged to think (other than hanging a sign on his wall)?

Another contributing factor to the "killing" of thinking in the executive is the organization of functions into hierarchies with specialization of function to get mass production. This is known as bureaucracy. And one of the basic problems of bureaucratization should be seriously considered. That is its stultifying effect upon executive thinking.

Thinking can only survive in the fertile field of spontaneity and a reasonable degree of individual freedom. Therefore, to teach an executive to think, he must first be allowed the necessary freedom to disagree and "think" through the solution to the problem. Paralyze the executive in his thinking about the fundamental problems of his present position and he will hardly be ready to throw himself with enthusiasm into the higher ex-

ecutive positions. This will become more apparent as we look further into this "thinking" subject.

Why Think? The basic reason for the executive to think is to solve problems and make recommendations. This is



in contrast to the executive who continues to carry out assignments but only because he has found it easy to do just what his supervisor wants.

In addition, thinking will help him formulate beliefs about existing and future solutions of problems. Thinking also affords the executive enjoyment. With a well-stocked mind he can imagine new situations and take pleasure in reviewing past successes. While reviewing the past problem-solving successes new ideas will emerge and contribute to the solution of other problems.

Before we can teach a person to think we must know what we are teaching. A definition then, is in order.

Reverie and Reason. Thinking is a sequential arousal of symbols. These symbols or "ideas" are based on knowledge or recall of the past. The more experience an executive has in solving problems the more ideas he can recall and apply to new problems. These symbols may be words, images, gestures, ideas or final consequences of past actions.

There are two main types of thinking. Reasoning and reverie. In reverie the thinking is random, as in daydreaming. This type of thinking adds little to realistic problem solving.

On the other hand, reasoning is constructive because it is directed and controlled. The reasoning begins with a problem and ends with its solution. As an example, if the problem is to get an unworking automatic washer started, we think of things that might be amiss with the washer, not of unrelated things as in daydreaming.

Three "Think" Stimulators. In teaching an executive to think, certain types of mental problems can be used. Whether the problem itself is related to his work is immaterial at first.

1. The first consideration is that he recognize the steps and freedoms he must use to solve the problems. Present the drawing shown directly at left with instructions to trace each line without repeating any line or raising the pencil from the paper.

You will notice that there is a tendency to begin in the upper left hand corner. This is generally due to past experience in reading habits and, if used in this case, makes success impossible.

This tendency, to let past habits shackle thinking, is probably the greatest handicap to successful problem solving.

The executive who can pull himself away from the left to right reading habit and make shifts and wide variations on this particular problem is on his way to being a successful thinker.

2. Another deterrent to productive problem solving is a preconceived notion or assumption. If the executive cannot use materials or ideas in new ways or discard the preconceived notion he is limited in his ability to think through and solve problems. Use the following problem to test your "pupil."

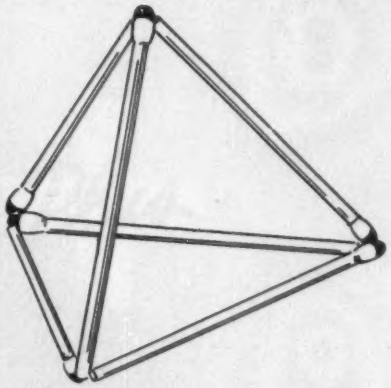
Provide a string of beads consisting of two colors. The problem is to regularize the color pattern without unstringing or restringing them or breaking the thread. The string, with a square representing black and a circle representing white, should be presented as follows:

○■■○■■■■■○■■○■■

Of course, the solution is to do away with the three extra black beads in the center. The only solution is to break the beads with some available "tool." To do this the executive will have to overcome his "preconceived notion" that the beads, too, must not be broken. This, of course, is not the case and was not in the instructions.

After working such problems this "breaking away from the preconceived notion" will become a working tool in future problem solving.

3. Another problem to test an executive's ability to avoid unnecessary assumptions is done with six matches. The instructions are to make four equilateral triangles without breaking the matches. If the executive assumes that the construction will lie in a plane he will be unsuccessful. He will probably say you "tricked him" when you show him the following solution.



The fact that he did not "think" of this 3-D solution to the problem shows that he made an unnecessary assumption. As stated before, executive thinking depends upon "freedom" of thought. If past habits, notions and unnecessary assumptions are hampering the executive's thinking then his attention can be called to it by the use of the above problems. Such problems call for turning and twisting and some detouring, which is contrary to a person's natural feeling of straight forward progress.

But it is this mental ability to deviate from past habits and natural inclinations that makes an executive valuable in problem solving.

These exercises will reveal to the executive the progress of problem solution. First, of course, the problem presents itself, a "hunch" or hypothesis emerges, and then a trial run or test of the hypothesis. In other words, the executive must see what there is to be done and what there is to work with.

The measure of how deeply and broadly the executive thinks in regard to the material with which he works, can be ascertained.

Shallow vs. Deep Thinkers. For example, the shallow and narrow thinker is more apt to stick to the common use or definition of an object or idea. When asked to enumerate the uses of a lead pencil he will usually respond with, "To write and to erase."

An executive with depth and breadth of thinking will list many

uses. Such as; to write, to erase, to poke, as a lever, as a pin, as a splint, and many others.

A thinking executive will use materials and ideas at hand in many ways for which they were not originally intended. This ability to see new uses for old material and ideas in the solving of current problems is an indication that the executive is following the motto: THINK.

However, it must be remembered that, taken by itself, thinking has no responsibility. It is not an end product; it is essentially a mechanism which has been found to be fundamental to the fruitful operation of any business.

An executive must also remember to "think about his thinking." Or he may find himself on the bosses' carpet saying, "I thought, without thinking, that . . ."

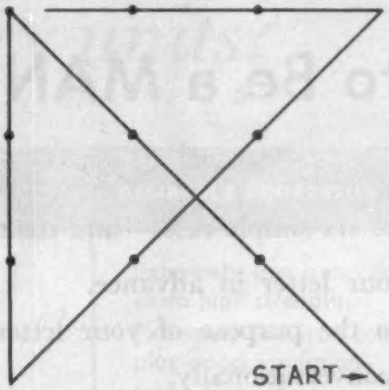
Avoid "Blind" Thinking. If random, blind groping, trial and error thinking is used there will be many false steps, valuable time wasted and possibly minor disasters. However, controlled trial and error, that is the trying of various ideas because of inability to see in advance which idea will prove successful, can be used to advantage.

In using this method the executive is trying only the combination of ideas that makes sense. There may be many false leads, but there would be no irrelevant behavior such as trying every idea that popped into mind.

In trying different ideas in the solution of a problem a restricted "mental set" can interfere to the degree of prohibiting a solution altogether. The following problem will illustrate how a restricted (by boundaries) mental set can interfere with the correct answer.

The instructions are to connect the nine dots by drawing four straight lines without raising the pencil from the paper or retracing. Using controlled trial and error one idea after another is tried. All ideas that concern the dots and does not comply with the instructions are discarded. This is a necessary mental set.

But there may be another mental set not concerned with the instructions. This is the set that restricts the lines to the area bordered by the dots. As long as this type of thinking prevails the problem will not be solved. But when the mental set is broken and "free" thinking makes it possible for the lines to go beyond the boundary of the dots, a solution can be found.



This emphasizes the importance of going beyond everyday habits and routine thinking. And, to repeat, such problem solving calls for "freedom of thinking."

Concrete vs. Abstract. In addition to the above diagrammatic problems, language problems can be used. In fact, linguistic problems compel the executive to use additional mental processes in his thinking.

Major among these is imagery. When confronted with a language problem a mental picture (image) must be "drawn" because none has been supplied as in the diagrams used above.

Language problems, such as the one below, come closer to the realistic problems the executive faces than does the diagrammatic. For, generally, everyday business problems are not neatly drawn out with a set of instructions attached.

Before presenting the following language problem the executive should be cautioned to avoid the "mental pitfalls" encountered while working the diagrammatic problems.

A traveling salesman ran out of money while staying at a motel and his expense check would not arrive for 23 days. He suggested to the proprietor that he be allowed to pay his daily bill with a heavy gold watch chain of 23 links. The proprietor agreed to accept a link on each successive day and return the chain when he received his money. How many links does the salesman have to cut in order to pay his bill? The answer is 2 links.

After divulging the correct answer the real problem arises. How did one arrive at such an absurd answer?

In solving this second problem the executive will have to look at the stated facts in different ways, seek new meanings and look for new combinations. Otherwise speaking, he must develop mental flexibility. Eventually he will find that 2 *is* the correct answer.

Another language problem that brings forth still another mental process is the one which leaves out, so it seems, some necessary directions. The final question seems completely disconnected from the stated facts. For example:

A hunter left his camp one morning and walked one mile south. Then he turned west and walked one mile and shot a bear. At that point he was an equal distance from camp as when he turned west. What color is the bear?

At first examination there seems to be no clues in the given facts as to the color of the bear. Upon closer scrutiny, and more important, after giving "freedom" to the thinking processes the answer suddenly appears.

In solving such problems the solution comes by proceeding from the concrete to the abstract. Abstracting is observing the similarity of otherwise different things. Such flexibility, in many instances, must be taught.

The aim of this article is not to exhaust the topic of thinking, but to indicate rather generally and by a few examples a partial solution to the problem of teaching executives to think. As stated previously, they cannot think if they do not know how or if they are not allowed mental freedom.

The foregoing is a suggested way to bring the attention of the executive to the proper process of thinking. This may enable him to address himself in a spirit of confidence to the central business problems of our time.

Executives do not need to be prodded to face up to these problems—they will be ready enough to do so if given a measure of freedom, instructions, and backing.

Members of top management can help by pointing out that such freedom and backing is precisely what the executive can expect. By speaking out in this way they would help to lift a little the weight of uncertainty that now chokes off thinking. # #

How to Be a MAN OF LETTERS

Follow these six simple rules—and make your letters sparkle:

- **Plan your letter in advance.**
- **Stick to the purpose of your letter.**
- **Write conversationally.**
- **Avoid large obscure words.**
- **Eliminate those "horse and buggy" phrases.**
- **Make it attractive.**

HIGH COLLARS, handlebar mustaches, button shoes and the derby were quite the style once but have long since faded from the American scene.

There are, however, a few reminders of that Gay Nineties period, and one of them is the businesss letter, which in many cases is still struggling along in typical turn-of-the-century style.

Although times and styles have changed, many are still writing letters using words and phrases of 1890 vintage.

You've undoubtedly seen plenty of examples of these "dead language" letters. Are these expressions familiar?

"Please be advised" . . . "In reply to your letter of the 12th" . . . "Yours of the 15th inst. received" . . . "Replying to yours of . . ."

This is only a sampling of the many bewhiskered phrases that make many modern day business letters dull and lifeless.

A business letter isn't expected to read like a page from a best-selling novel. No one expects it to. Its purpose is either to provide information or request information. A business letter should be short and concise and should get across an idea in the simplest, easiest-to-read and most understandable style. And anybody who can talk can write a business letter. After all, a letter is nothing more than a conversation on paper, a substitute for personal contact.

The rules are simple. Follow them and you can become a successful letter writer.

1. Plan your letter in advance. You wouldn't think of giving a speech without planning what you were going to say to your audience. Why write a business letter without advance planning? Two or three minutes spent in marshalling your thoughts will simpify your job and will pay off in the reader's acceptance of what your letter says.

2. Stick to the purpose of your letter. Know what you're going to say and stick to it. Leave the extraneous stuff out. The object of your letter is to provide your reader with information. Skip the chatter that goes beyond that. Remarks about the weather may enliven

PLAN YOUR LETTERS IN ADVANCE

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Which are best to use in refinery units?

Naturally, the type of refractory castable selected depends upon the specific service. B&W makes a line of specialized refractory castables which are being widely used in catalytic reformers and catalytic cracking units, as well as in furnaces, ducts and stacks. For easy reference, here are some typical applications together with the recommended B&W Refractory Castables:

APPLICATION	DESIRABLE PROPERTIES	RECOMMENDED B&W CASTABLES
Linings of catalytic reformers	Extremely low iron content, extra high strength. Extremely low iron content, plus good insulation. Low iron content, high temperature use limit.	Kaocrete LI Kaolite LI Kaocast
Lining desulphurizers	Good workability	Kaocrete B
Transfer lines and regenerators of catalytic cracking units	Extra abrasion and erosion resistance.	Kaocrete D
Heads of reactors and regenerators	Plasticity, excellent workability.	Kaocrete B
Insulating furnace floors	Good insulation, light weight	Kaolite-20 Kaolite-22
Tube sheets	Good insulation, light weight	Kaolite-20 Kaolite-22
Burner blocks	High temperature use limit, refractoriness and spalling resistance.	Kaocast
Openings where doors and other points are subject to mechanical abuse	Extra abrasion and erosion resistance	Kaocrete D
Furnace doors	Good insulation, light weight	Kaolite-20 Kaolite-22
Ducts and stacks	Good insulation, light weight	Kaolite-20

Bulletin R-35 contains additional information on B&W Refractory Castables. Send for your copy.

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R-862

WRITE CONVERSATIONALLY

a dull conversation, but they slow down the pace of a letter.

3. Write conversationally. Write as you speak. There's nothing at all wrong with good, ordinary language with one-and two-syllable words and short sentences. There was a time when business letters were staid and conservative to the point of stuffiness. But times and business letters have changed.

Your personality is revealed in the way you converse. Retain that personality in your letters by talking, not writing.

Too, direct your letters to the personality of your reader. If he's the kind of fellow who's deadly serious all the time, your attempts at humor could rub him the wrong way. If he appreciates a quip now and then, he's a natural for a letter in a lighter vein. Don't get carried away, though. Remember, you're still writing a business letter, so moderate your humor. You can be businesslike and friendly without gushing.

Have confidence in what you write. If you don't believe what you're saying, don't write it. An unsure or insincere letter is worse than no letter at all.

Don't "write down" to your reader. A patronizing attitude on your part stands a good chance of irritating him. Strive for the man-to-man approach.

AVOID LARGE OBSCURE WORDS

4. Avoid large obscure words. You're probably familiar with the schizophrenic letter writer. He converses in an easy, informative manner, but undergoes a startling change of character when writing a letter. He goes "literary"; his sentences become long and involved, laden with many-syllabled, unfamiliar words that send the reader to the dictionary (or the letter to the wastebasket). "King's English" is okay for kings, not for business letters. Don't try to impress your reader with your vocabulary. That's not your purpose. Large obscure words can be misinterpreted. The reader may not know the meaning; you may not know it yourself. You want your reader to get the point of your letter quickly, without "digging."

5. Eliminate those "horse and buggy" phrases. These trite and meaningless expressions went out before the bustle, but you can still find them in use. The "beg to advises," "instants of the 16th," "acknowledged receipt ofs" and numerous other overworked phrases are dead. Why not bury them? They add nothing to a letter but a stuffy atmosphere and the feeling that you and the company are out of date.

Do any of these look familiar?

acknowledge receipt of—Unnecessary; if you're answering a letter you must have received it.

agreeable to your request—Phooey! That isn't how you'd say it if you were talking.

as the case may be—Sound and fury, signifying nothing.

at the present writing—what's wrong with "now"?

beg to advise—Don't be a beggar. Stop advising, start telling.

due to the fact that—Use "because" or "since" and save four words.

enclosed please find—Use "enclosed is" (he'll find it if you didn't leave it out).

for your information—Save your breath. Anything you say is for his information.

deem it advisable—How often do you "deem" in a conversation?

in the near future—When's that? Tomorrow . . . next month. Be specific.

wish to thank you—Don't wish. Thank him and leave out the preliminaries.

as per your order—Why "as per" anything? "Per" is only appropriate in Latin phrases, as per annum, per capita. Say "three dollars a day," not "per day."

under separate cover—Okay if you're speaking of someone in bed. Be specific: "by express," "by parcel post," etc.

6. Make it attractive. Once your letter is written give it the eye-appeal test. Is it top heavy? Is it badly spaced? Keep it free from smudges, partial erasures and haphazard folds.

The business letter you write reflects on both you and the company. Ask yourself if the letter you have just written is one you would want to receive. If the answer is "no" don't mail it.

There's nothing mysterious about letter writing. It's easy if you follow the rules. Develop good letter writing habits and you'll become an able representative of your company without ever leaving your desk. You too can be a "man of letters."

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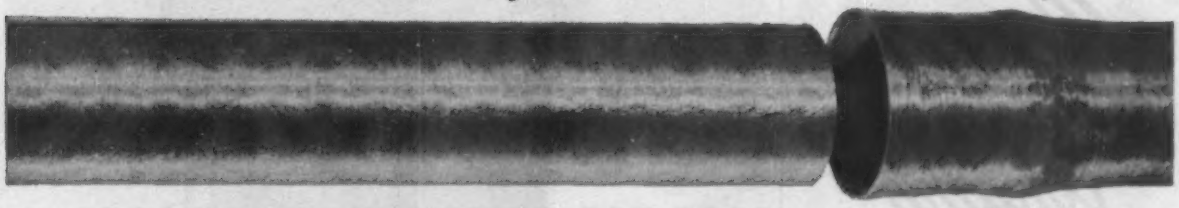

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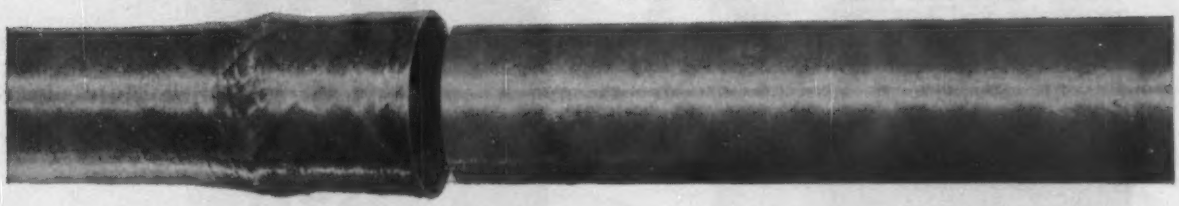

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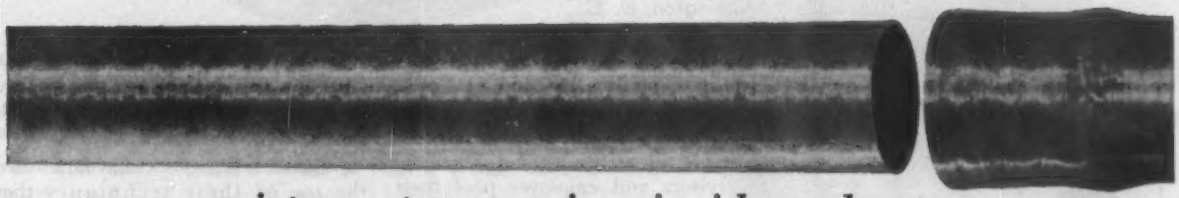

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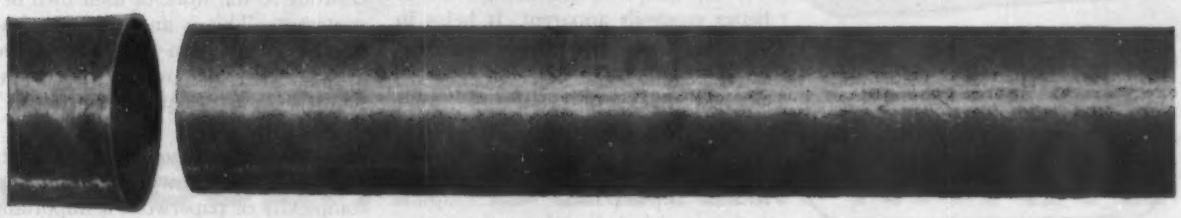

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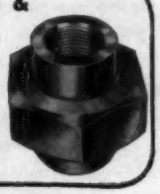

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Do You Use WORK SIMPLIFICATION?

Here is an efficient way to streamline your supervisor's work load.

Dr. Robley D. Stevens
Management Consultant
Washington, D. C.

THERE IS ALWAYS a better way of doing a job in any refinery. Better methods, improved tools, better working conditions, shorter procedures—these all can be discovered when the supervisors and employes pool their efforts.

Work simplification makes these better methods apparent. It helps in avoiding bottlenecks, low output, red tape, backlogs, overtime and low morale. In short, work simplification is an action program which pays big dividends when applied.

Aid to Supervisors. Work simplification is aimed directly at the supervisor as a method of attacking problems by equipping him with the skill and know-how to analyze and improve existing department methods and procedures. It seeks to impart skill in the use of these techniques:

1. *Work Distribution Chart,* a device for analyzing division of labor.
2. *Flow Process Chart,* a device for analyzing *flow* and *sequence* of work.
3. *Work Count,* a device for interpreting facts about the volume of work.
4. *Motion Economy,* which stressed the elimination of *unnecessary motions* by the workers.
5. *Layout Studies,* which economize on time, distance and space, and provide better working conditions.

Supervisors should be taught to gather relevant facts quickly, to organize them in simple chart form and to interpret them accurately. Work simplification is not a single "shot in the arm," but the supervisor can continue to use the methods learned as a matter of course in solving everyday work problems.

When the supervisors have mastered the use of these techniques they should be expected to apply them successfully to the work of their own departments. This is an important feature of the program and can produce a saving in time, money and manpower over a long period of time.

Eliminate Excessive Paper Work. Obviously, the growing volume and complexity of paperwork is important to every refinery. Management is concerned not only with accuracy and economy, but also with the large amounts of time and clerical effort required to get things done.

Work simplification attacks the mass paperwork problems which effect every oil company employe. It will also aid employes to think about better ways to increase production and cut down costs.

The refinery supervisor is the one person who is constantly face-to-face with the realities of running his department. Much of the paperwork problem resolves around his desk or workbench. The supervisor must know work requirements and problems at first hand—and the one who does the job is the one who is in a good position to do a job better. This applies to developing improvements and to getting action on improvements after they are developed.

Following are the techniques that

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SOLVAY Sodium Nitrite forms an invisible gamma oxide protective film that keeps metal surfaces corrosion-free. You can easily dip or spray it in solution, or add it to circulating water systems. Effective with steel or iron, it also reportedly suppresses degradation in aluminum, tin, monel, copper and brass. Where a more moisture resistant film is required, it can be combined with phosphates.

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Methylene Chloride • Para-dichlorobenzene
Methyl Chloride • Cleaning Compounds • Soda
Ash • Hydrogen Peroxide • Aluminum Chloride
Ammonium Bicarbonate • Carbon Tetrachloride
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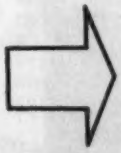
An operation represents the main steps in the process. Something is created, changed, or added to. Usually transportation, inspections, delays, and storages are more or less auxiliary elements. Operations involve activities such as forming, shaping, assembling, and disassembling.



Transportation is the movement of the material or man being studied from one position or location to another. When materials are stored beside or within two or three feet of a bench or machine on which the operation is to be performed, the movement used in obtaining the material preceding the operation and putting it down after operations are considered part of operation.

Inspection occurs when an item or items are checked, verified, reviewed, or examined for quality or quantity and not changed.

A delay occurs when conditions do not permit or require immediate performance of the next planned action.

Storage occurs when something remains in one place, not being worked on in a regular process, awaiting further action at a later date, permanent storage or disposal.

comprise the work simplification program:

Work Distribution Chart shows a refinery's division of work. It helps you ask and get an answer to: What activities take the most time? Is there any mis-directed effort? Are employe skills being used properly? Are your employes doing too many unrelated tasks? Are tasks spread too thinly? Is work distributed evenly?

A work distribution chart is the easiest and best way to arrange these facts in simple form. A properly made work distribution chart will help you to determine if the largest total time of your employes is devoted to the major function of your organization. It is the basis of work improvement effort.

The work distribution chart is a device for arranging facts about work in a clear, understandable form. You get the facts from the task lists which are prepared by each worker, stating in brief, specific and factual terms what he does.

Flow Process Chart shows the sequence of work and enables you to trace the work step-by-step. It helps you ask and get an answer to: What is done? Why is this step necessary? Where should this step be done and can it be done easier? Who should do the job and is the right person handling it? How is the job being done? Such scrutiny helps the supervisor locate and eliminate unnecessary steps.

Work Count shows a refinery's volume of work and assists in determining the method of doing the job. It helps you—schedule work, relate tasks, divide work, locate bottlenecks, demonstrate personnel needs, and stimulate worker interest. A prudent supervisor will correct the trouble before it is found out by someone else.

Motion Economy shows you how to produce the best results with the least physical effort. It is not a speed-up, but an elimination of waste motion and nonproductive effort. It shows how to provide the best working conditions for your employes and shows the shortest travel distance for materials, papers and workers; it is particularly useful in identifying opportunities for the application of management engineering principles.

Motion economy is doing in the best way those things that need to be done, and eliminating those tasks where the cost exceeds the value of the product.

What's the easiest way to get work information? From the employes themselves. Each employe should prepare a task list which shows how much time he spends each week on each task he performs.

To help supervisors see at a glance just what steps are taking place during a work simplification process, five simple signs are generally used. Above is the sign language used in making a flow process chart. These symbols have been tested in thousands of cases and have proved to be the simplest way of highlighting the step-by-step detail of the work process.

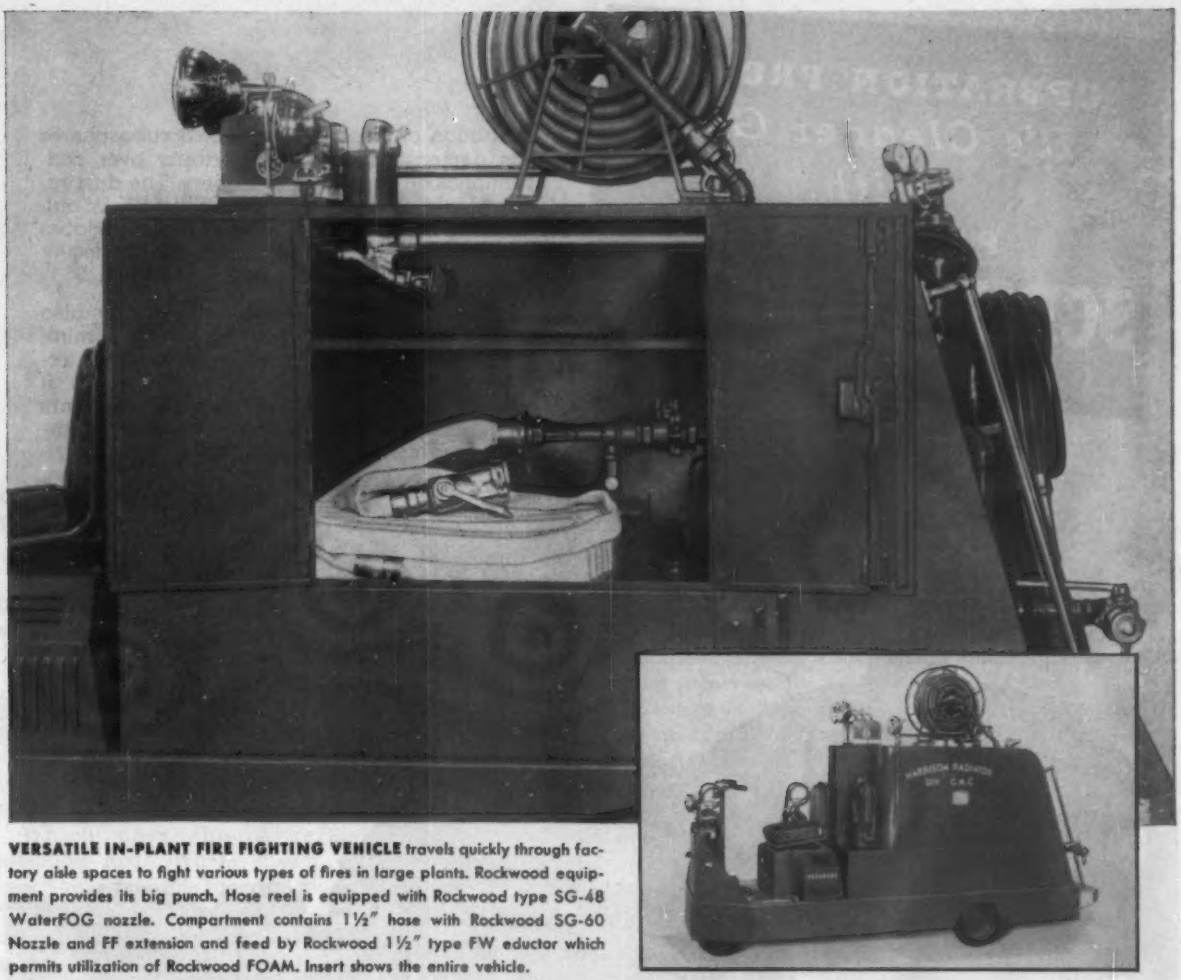
It is always wasteful to have personnel working below their skills. And when manpower is short, the proper use of employe skills is particularly important. Work simplification will help reduce the waste of employe skills.

Supervisors are judged by visual and tangible proof of productivity. Their worth is measured in terms of the flow of quality products, the cost of production, the apparent morale and industry of workers. This means that the supervisors set the value of their services by using work simplification control over work performed.

But like a suggestion system, a work simplification program is one for improving employe efficiency, increasing production and reducing costs. An effective work simplification program starts with selling ideas to company employes. The people who do the work must participate in it if the work simplification program is to get results.

But if there is to be progress—simplification of your paperwork problems—it will come only as a result of a carefully prepared program. You can go about this by appointing a top management representative as your agent to carry out the program. It will be his job to see that work simplification keeps a full head of steam. Instruct him to report to your engineering department if it shows signs of bogging down.

Select the places in your refinery where work simplification should begin. Experience indicates that work simplification pays the biggest, quickest dividends in streaming routine repetitive processes. ##



VERSATILE IN-PLANT FIRE FIGHTING VEHICLE travels quickly through factory aisle spaces to fight various types of fires in large plants. Rockwood equipment provides its big punch. Hose reel is equipped with Rockwood type SG-48 WaterFOG nozzle. Compartment contains 1½" hose with Rockwood SG-60 Nozzle and FF extension and feed by Rockwood 1½" type FW eductor which permits utilization of Rockwood FOAM. Insert shows the entire vehicle.

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The Young Fire Equipment Corporation of Buffalo, New York, made this vehicle an even more potent fire fighter by installing Rockwood fire prevention equipment.

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Rockwood FOAM is automatically proportioned (97 parts water to three parts FOAM) and introduced into the hose line by the Rockwood FW eductor. The Rockwood SG-60 WaterFOG nozzle fights fire five ways — by means of a solid water stream high-velocity WaterFOG, low-velocity WaterFOG from applicator, and from FF extension inserted in nozzle, a wide angle FogFOAM pattern and a solid FOAM stream.

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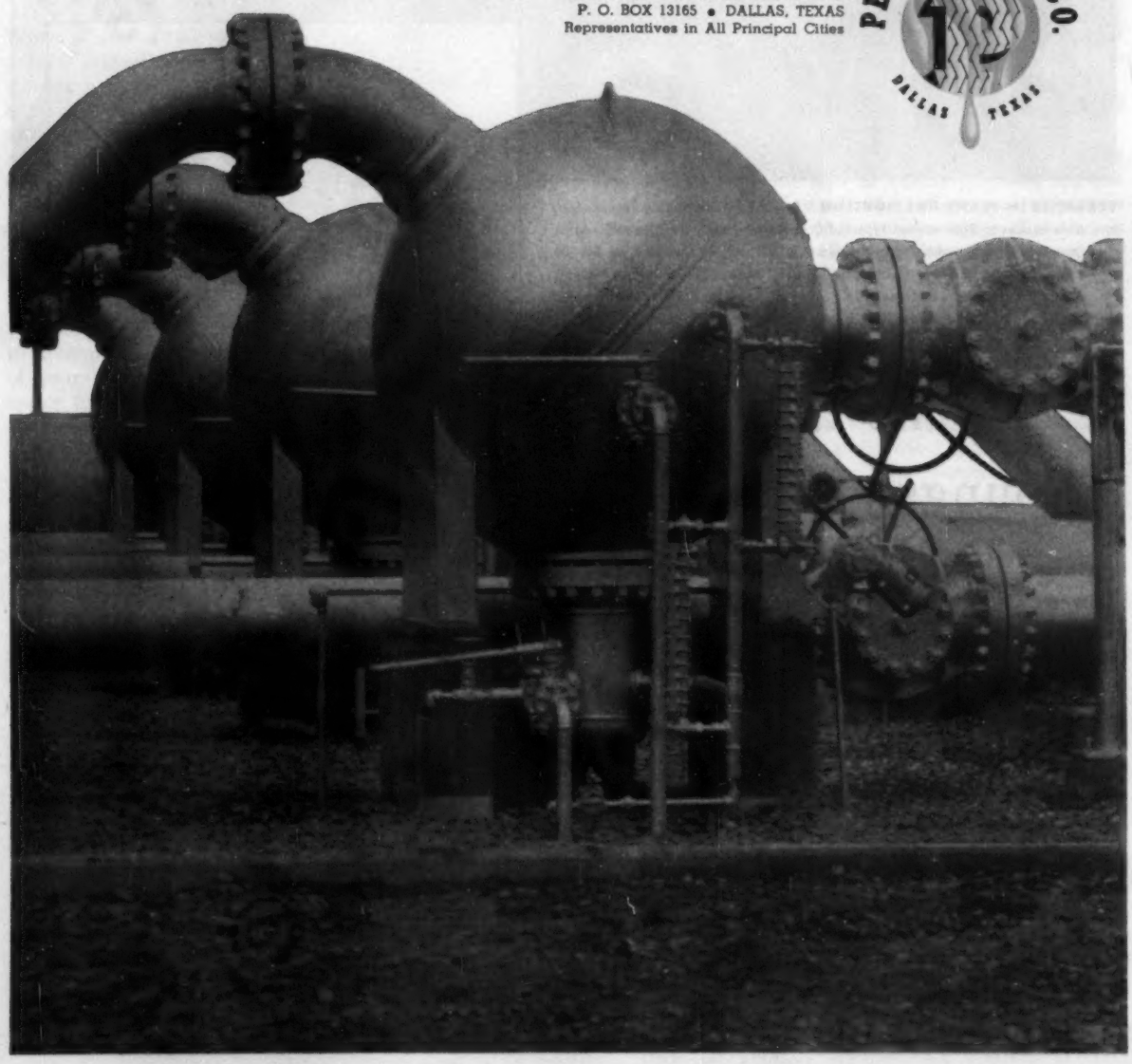

How to Determine Training Needs

Here is a formal approach that has paid off for several oil companies.

Carl Mullins White
Tulsa, Oklahoma

THE NUMBER of possible good training projects is unlimited. The ultimate question is:

"What training do you need most?"

Your company might offer courses in job skills, company policies and procedures, or safety. There are courses in human relations, supervision, executive development, orientation, and general interest subjects.

Which ones should receive attention first? Where should you spend your available time and money?

Oil companies employ many different methods in their efforts to answer these questions. Their methods could be divided for convenience into two classes, formal and informal.

This article describes one formal method of determining needs for training in job skills.

This practical means, used by many large oil companies, is conducted by the line supervisor with the advice and of a training specialist.

The procedure, like all procedures for determining training needs, falls into five steps:

1. **Adopt Goals**—decide what you want employes to do (or believe).
2. **Take Inventory**—find out what employes' present qualifications are (skills, knowledge, attitudes).
3. **Determine Needs**—subtract item 2 from item 1 and classify the results in useful form.
4. **Evaluate**—check your training projects, past and present, against item 1.
5. **Review**—periodically repeating the above four steps.

Adopt Achievement Goals. Deciding what you want employes to do depends first of all on job description. If a company already has a job analysis program in effect, the supervisor should first take full advantage of it.

He then lists all the jobs in his section. Under each he lists and describes all the details or tasks included in that job.

If he anticipates any expansions, promotions, or improvements in his section, he adds the tasks that will be needed.

Take Qualifications Inventory. The next step is to take an inventory of the working force. The supervisor prepares a personnel status chart. This begins with a list of all his employes by job classification. Then, from the job descriptions (Item 1), he lists under each the tasks which that worker is expected to perform. He classes each task according to the worker's ability to perform it as:

a. Performs effectively.
b. Needs specified improvement.
c. Needs basic training.

The supervisor should use care in tabulating these tasks and in evaluating his employes' skills. In some cases, the problems will be simple. For example, he may have recruits or transferees who obviously need full basic training in all job details. In other instances, the decisions may be highly involved. The supervisor should have all the specialized consultation that he needs. But, he is responsible. He must protect the company against expenditures for unneeded training, and against an even more expensive item—the inadequately trained employe.

Determine Needs. The third step is to ascertain training deficiencies

FIVE WAYS TO DETERMINE TRAINING NEEDS

Adopt Goals—*decide what you want employes to do (or believe).*

Take Inventory—*find out what your emyloyes' present qualifications are (skills, knowledge, attitudes).*

Determine Needs—*subtract item 2 from item 1 and classify the results in useful form.*

Evaluate—*check your training projects, past and present, against item 1.*

Review—*periodically review the above four steps.*

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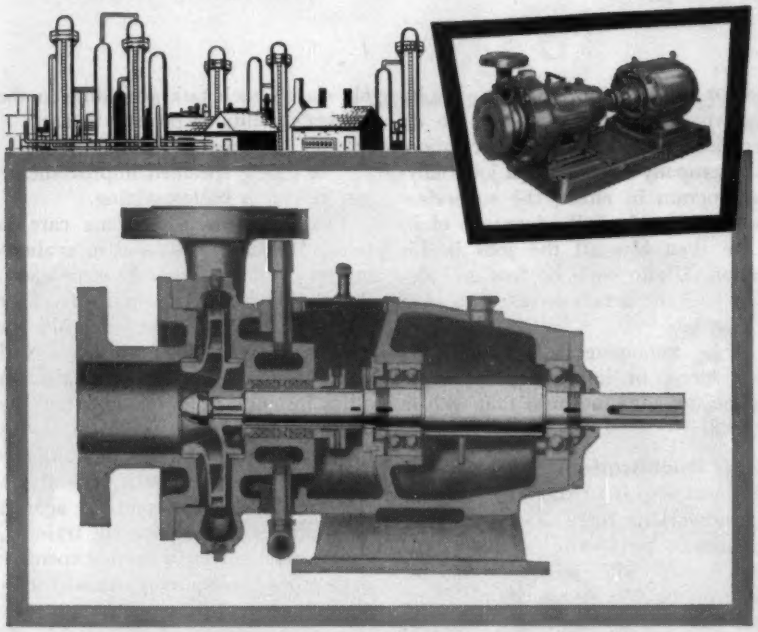

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and arrange them in units so that plans can be laid to meet them. This is usually done by:

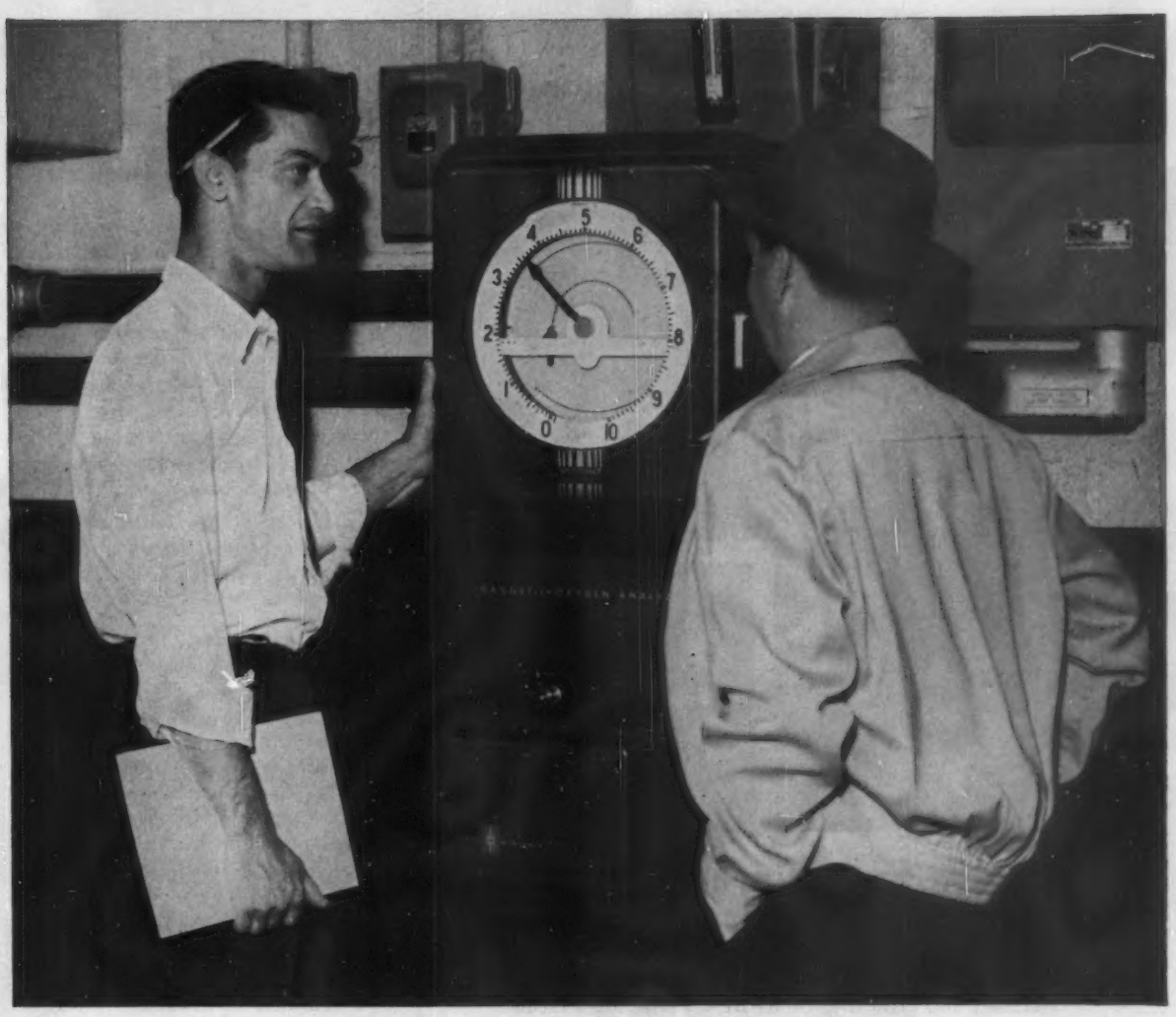
a. Determining individual training needs (goals minus inventory).
b. Spot checking for indicators of training needs.
c. Deciding on the classroom or individual instructon that will be needed.

Individual Training Needs. A personnel status chart will give the supervisor definite information on his work force. He considers the workers he will lose through transfer and termination. There may also be additions to his force for various reasons. He has to foretell what worker skills he will need in the future. He gets the information for this forecast from several sources. These include sales and production forecasts and labor turnover records. Retirements can be obtained from personnel files. On the basis of his own records and all other information he can gather, he tries to forecast his training requirements.

Spot Check for Indicators of Training Needs. Spot checking for training needs is usually done company-wide by a training specialist, with each supervisor cooperating wherever it involves his unit. It consists of a re-check for such factors as:

1. Limited experience of some employes:
   a. New employes.
   b. Transferred employes.
   c. Promotees.
   d. Ineffective working habits.
2. Organizational changes:
   a. New equipment.
   b. Conversion of equipment.
   c. New operations or procedures.
   d. Expanded operations.
3. Output problems:
   a. Excessive re-work.
   b. Breakage.
   c. High unit cost of production.
   d. Lowered performance standards.
   e. Production bottlenecks.
   f. High maintenance costs.
4. Personnel problems (more related to human relations training):
   a. Excessive overtime.
   b. Grievances and complaints.

If any information gained in the spot surveys affects the supervisor's training of his employes, it should be made available to him. He should



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The Unitized O_2 Analyzer is reduced to the essentials consistent with highly efficient O_2 measurement and control. The entire analysis is made within the 2-component team of O_2 Analyzer Assembly and Speedomax® recorder, eliminating unwieldy auxiliary components such as sample conditioners. Due to its direct magnetic operation, the equipment employs neither auxiliary gas supplies, chemical reactions, nor combustion. Sample and calibration controls are accessible externally, without disturbing the measuring system.

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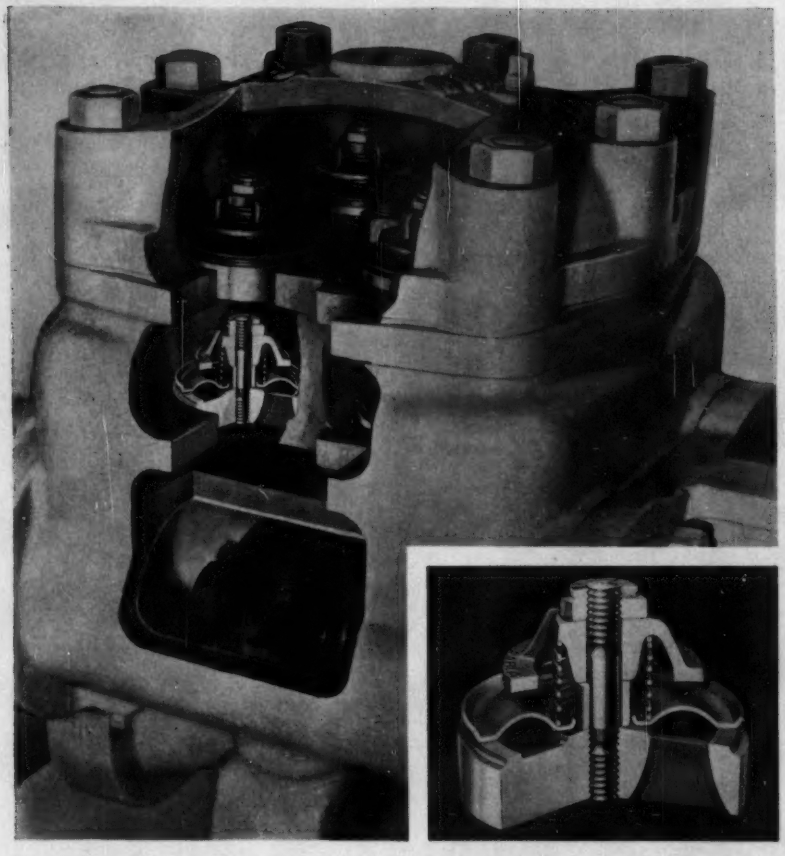

The valve for reciprocating pumps . . . old or new

Because they offer a happy combination of dependability, efficiency and extra life, DURABLA Valves are a credit to any reciprocating pump. Mechanically and metallurgically speaking, they will operate freely under temperature-pressure extremes, with highly corrosive fluids and in any position.

In a DURABLA Valve Unit, only "point contact" is made by the valve member on the sleeve, so it can't bind or hang-up. Due to its unique arched design, neither will it warp. The new V-7* taper-locked stud can be screwed down tight into the seat without any possibility of galling or breakage. And a self-locking nut and "drop-on" guard assure quick and easy inspection of working parts —without stud or seat removal.

Standard equipment on many new pumps, DURABLA Valve Units are also used throughout the world to re-valve older pumps. They come in fifteen sizes, designed to meet over 300 variations in installation requirements.

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DM-34

add it to what he has learned from his own records and take full advantage of it.

Decide on Plans. Here again the supervisor usually needs the advice and assistance of a training specialist. He must decide:

- What training can be done in classes (either in his own unit or in conjunction with other units).
- What training must be taught individually on the job by himself or by one of his skilled workers.
- What information can be best gained by the employe from some outside source.

He can save the company's money whenever he can combine employes in a class instead of teaching them one by one.

Evaluate Results. Once a training project is started, evaluation becomes an essential part of determining training needs. The company must make a continuing series of decisions. Should any certain program be repeated as the need arises? Should that program be dropped in favor of some more effective or more badly needed one? Should it be reorganized? How long should it continue?

The supervisor keeps a current record of what each worker is taught. This record may include:

- Tasks to be learned.
- Estimated hours of training required.
- Dates instruction begins and ends.
- Hours of each type of instruction given.

He submits a summary report to management. This information helps in weighing costs against results.

Some of the methods for evaluating the results of training are:

- Production records.
- Cost records.
- Estimates.
- Tests.
- Expert opinion.

Whenever possible it is advisable to measure training results in simple financial terms. This is not to say that there are not highly important intangible and long-range values in training. But management likes to see figures to show training advantages. Production and cost records may show

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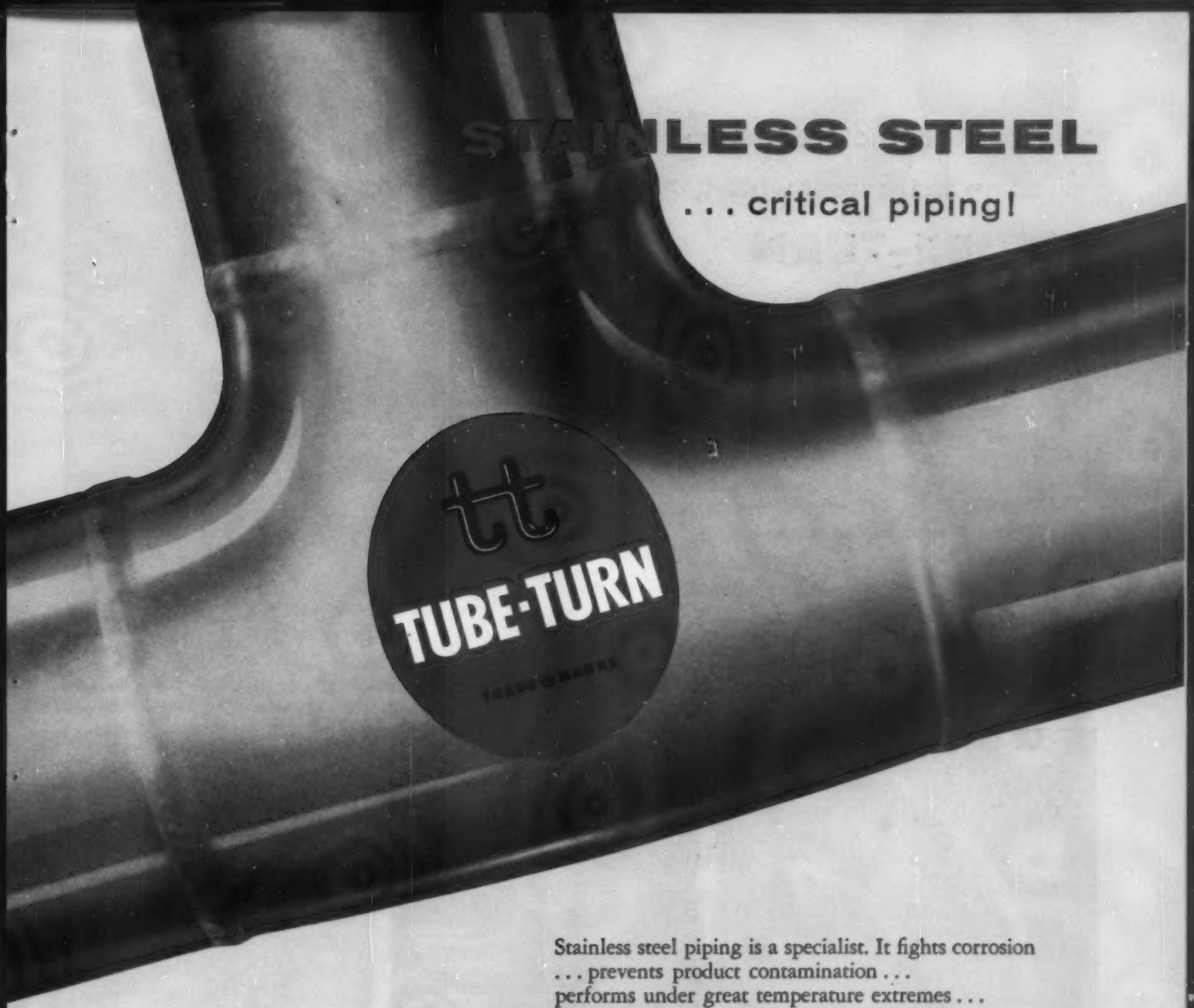

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Stainless steel piping is a specialist. It fights corrosion . . . prevents product contamination . . . performs under great temperature extremes . . . is able to handle dangerous materials safely. Construction and maintenance dollars, often the safety of life and property, and *your reputation* are at stake in the selection of these materials.

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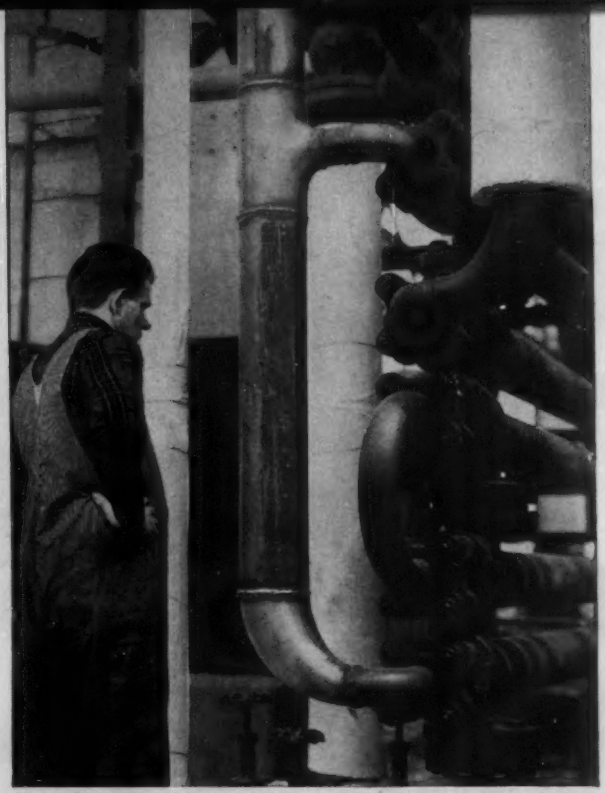

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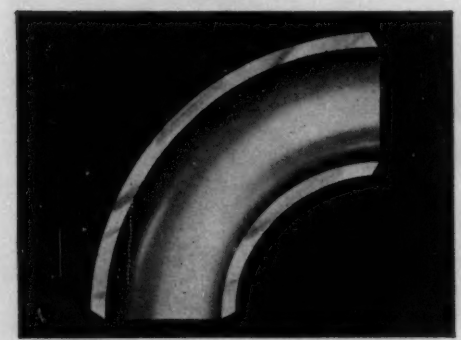

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that more goods were produced or that costs were less after training than for a comparable period before training.

Sometimes these comparative figures have to be based in part on estimates. The savings in power costs, breakage, and shut-down may be estimated by comparing actual figures kept on employes after training and comparing these figures with estimates of what these costs would have been had the employes not been trained. The value of estimates depends on the evidence behind them and the qualifications of the persons making the estimates.

Specially prepared tests are used by some companies to determine:

- Points on which employes need training.
- Which employes will profit by the training.
- When the training is adequate.

Tests, properly used, can save money by eliminating from the course those who are not ready to assimilate it and by terminating the training of individuals or classes which are ready to return to the job.

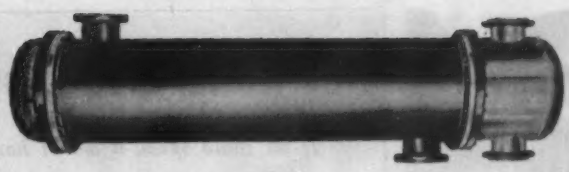
Merit ratings, promotions, and other expressions of expert opinions sometimes reflect the value of training. The supervisor can make a helpful estimate of the increased value of his workers. Also he can compare the cost of formal training with his estimate of what it would cost to train an employe by informal or apprenticeship methods. The facts considered in such estimates include:

- Employe's time spent in training.
- Supervisor's or other instructor's time.
- Breakage.
- Shut-down.
- Lost production.

Review. The final essential is to follow these four steps again and again. No company can ever say "we have completed our training" and fold its hands. Competition forces new mechanized equipment, new products, new methods. Employes come and go. People's skills and attitudes change.

To keep abreast, a company must repeatedly and discriminately:

1. List the skills it will need.
2. List the skills it has.
3. Subtract Item 2 from Item 1.
4. Evaluate its training activities.
5. Do it again. ##



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If Oil Could Speak

If oil could speak it would have many fascinating truths to tell the non-oil public—truths that would win thousands of new friends for the oil industry.

But, oil can't speak—you can. You, as an individual, can win many new friends for the oil industry if you will pass the true facts on to your non-oil industry friends.

Here are some of those true facts. They are being presented for one purpose: To keep you posted on your industry, so you can tell the story oil is unable to relate.

Read these facts. You will find them informative—and interesting.

How Much Gasoline Are We Using?

About 1.4 million gasoline pumps pour almost 48 billion gallons yearly into the fuel tanks of nearly 63 million automobiles, buses and trucks. This flow supplies liquid power for travel over U. S. highways that averages over a million miles every minute of the day.

Does the Oil Industry Pay Its Share of Taxes?

Oil companies pay more than their share. During the postwar years of 1946 through 1952, oil and gas producers paid roughly twice as much in U. S. income taxes on each dollar received as did the average industrial corporation.

How Much Does It Cost to Find Oil?

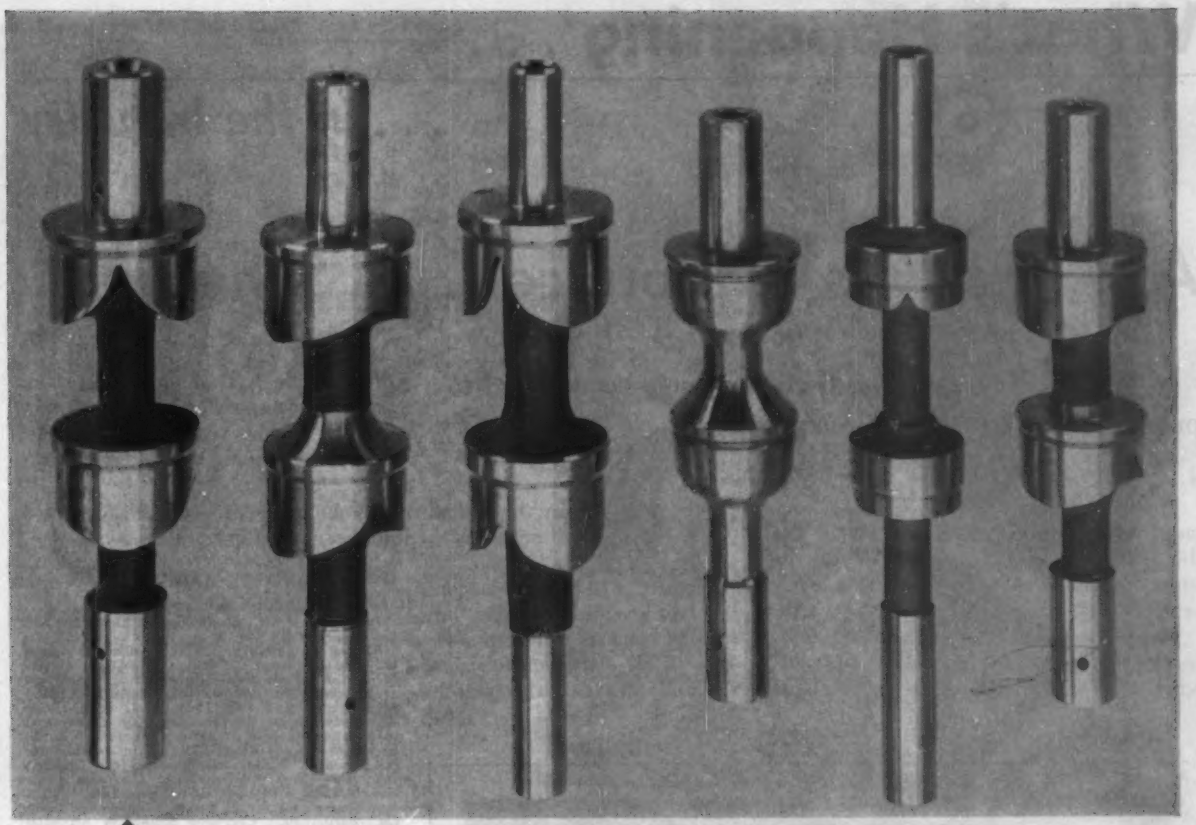
Oil and gas can only be replaced by finding new supplies; that is, new oil and gas reserves, and the finding of these reserves calls for extensive exploration programs, costing billions of dollars. On the average, a wildcat well costs $100,000, but some cost over $500,000. Only one in nine such wells strikes oil, therefore, on the average the oil man must invest $900,000 before he discovers one producing well. The manufacturer does not build nine factories before he finds one that will produce goods for sale, thus, the manufacturer spends $100,000 and is ready for business, whereas the oil man spends $900,000 before he gets any production.

Are Oil Profits Getting Bigger?

No. Oil profits have not kept pace with costs. The cost of drilling and and production has gone up. Since 1952, oil field machinery and tool prices have risen almost 25 percent; carbon line pipe has risen more than 68 percent; alloy casting is up nearly 56 percent—but crude prices are up only 23.3 percent! Oil prices must be adequate to make the risk of financing oil ventures worthwhile.

Are Major Oil Companies Doing Most of the Business?

Small, independent businesses, with little risk capital, drilled almost 78 percent of the wells completed in 1956. They risk not only their own money, but also the savings of thousands of investors all over the country. Oil men are hard pressed to get funds for investments that won't begin paying off for several years. Most of the output of oil wells being completed now will be used to meet increasing future consumption rather than current demand.



Inner secrets of inner valves

FACTS EVERY CONTROL VALVE USER SHOULD KNOW

This is a rare photograph . . . presented in a completely unretouched form. It shows the inner valve of leading makes of diaphragm control valves. The inner valve determines the control result.

The most amazing fact is the size . . . all are *listed* as two inch valves. All are high lift. But compare them.

Note the KIELEY & MUELLER inner valve at the far left. It equals the others on every point of consideration; exceeds on many. Look at the diameter across the skirt . . . that's one reason for the remarkable C_v of K&M valves. Look at skirt length; the solid, not fabricated, design. Measure the rugged guide posts and the large column. Examine the machining and the super-finishing.

It's no wonder . . . K&M is *the valve that likes to be compared*. It's a better valve and a better value by every measure of comparison.

FOR THE COMPLETE FACTS . . .
write for the K&M Valve Engineering Data Catalog, Bulletin CV53.

diaphragm control valves

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What's Happening . . .

. . . in the Industry

API Refiners Announce L. A. Schedule

New areas of discussion have been added to a program of 11 technical meetings.

Members of the petroleum-refining industry will gather in Los Angeles this spring for the American Petroleum Institute's twenty-third midyear meeting.

Eleven technical sessions and the traditional dinner meeting have been scheduled for the four-day gathering which opens May 12, in the Statler Hotel, and continues through May 15.

The number of technical sessions this year remain the same as last year, but the subjects differ to some degree. Slated for discussion this year are corrosion, analytical research, processes, fuels, training, air polution, and waste disposal. Also, for the first time in recent years, there will be sessions on piping and pressure vessels.

Preliminary program for the 23rd midyear meeting is as follows:

MONDAY, MAY 12, 1958

9:00 a.m. Corrosion

Presiding: P. N. Gammelgard, The Pure Oil Co., Chicago, Ill.

Session developed by C. H. Samans, Standard Oil Co. (Indiana), Whiting. "A Study of the Mechanism of the Iron-Hydrogen Sulfide Reaction at Elevated Temperatures," Fritz Hugli, Charles M. Hudgins, and Paul Delahay, Louisiana State University, Baton Rouge. "Corrosion Experiences in Sovaformers with Naphtha Preheaters," E. B. Backensto, Socony Mobil Oil Co., Inc., Paulsboro, N. J. and R. W. Manuel, Socony Mobil Oil Co., Inc., New York. "Solutions to Corrosion Problems in Light Hydrocarbons Liquids Plants," James S. Conners and C. L. Seyer, Phillips Petroleum Co., Bartlesville. "Corrosion Studies in Alkanolamine Systems," J. D. Sudbury, O. L. Riggs, and J. F. Leterle, Continental Oil Co., Ponca City, Okla. "A Refinery Chemical Cleaning Program for Profit," John Zahodnick, Esso Standard Oil Co., Linden, N. J.

2:00 p.m. Piping

Presiding: Clay Thompson, Mohawk Petroleum Corp., Bakersfield, Calif.

Session developed by J. P. Mooney, Humble Oil and Refining Co., Baytown, Texas. "The Influence of Prolonged Service at Elevated Temperatures and Pressures on the High-Temperature Strength of Chromium-Molybdenum Alloy Tubing," John F. Ewing, The Babcock and Wilcox Co., Beaver Falls, Pa. "Compressor Piping Design and Investigations Including Application of Computers to Piping Calculations," Ralph James, Humble Oil and Refining Co., Baytown, Texas. "Stability of Tubular Products for Oil Refinery Use," A. B. Wilder, United States Steel Corp., Pittsburgh.

2:00 p.m. Analytical Research

Presiding: Fred L. Hartley, Union Oil Co. of California, Los Angeles.

Session developed by B. J. Heinrich, Phillips Petroleum Co., Bartlesville. "A Mathematical Approach to Operating an Analytical Laboratory (Computer Simulation of Laboratory Operation)," G. V. Dyroff and F. E. Steidler, Esso Research and Engineering Co., Linden, N. J. "The Automatic Determination of Peroxides in Petroleum Products," Joseph S. Matthews and Joan S. Patchan, Gulf Research and Development Co., Pittsburgh. "The Determination of Sediment in Light Petroleum Products," F. A. Buehler and J. S. Wiberley, Socony Mobil Oil Co., Inc., Brooklyn. "Volatile Catalyst Components Determined Easily by the Leco Induction Furnace," Anne L. Conrad, Jean K. Evans, and V. Frances Gaylor, The Standard Oil Co. (Ohio), Cleveland. "Determination of Microgram Quantities of Sulfur by Reduction with Raney Nickel," Lawrence Granatelli, American Oil Co. (Texas), Texas City. "Quantitative Infrared Analysis of Polybasic Aromatic Acids in KBr Disks," D. E. Nicholson, Humble Oil and Refining Co., Baytown. "Micro-Carbon and Hydrogen Determination by Automatic Combustion Control," Ervin Stehr, The Texas Co., Beacon, N. Y.

7:30 p.m. Analytical Research

Presiding: Charles A. Day, Jr., Richfield Oil Corp., Anaheim, Calif.

Session developed by B. J. Heinrich, Phillips Petroleum Co., Bartlesville. "The Separability of Aromatic Hydrocarbons by Pentane Elution from Activated Alumina," Lloyd R. Snyder, Union Oil Co. of California, Brea. "Determination of Sur-

Platinum catalyst is guided into the new catalytic reformer at General Petroleum Corp.'s Torrance, Calif., refinery. Snowshoe-like shoes are worn to avoid crushing the valuable platinum pellets. Once vessels are filled and reformer is put into operation, the catalyst will be changed infrequently.

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At Beaumont — ultra-modern crude unit — capacity, 100,000 barrels per day.

At Houston — complete petrochemical plant to produce ammonia and methanol.

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Graham sales engineers are located in the following cities. You are invited to consult them without obligation.

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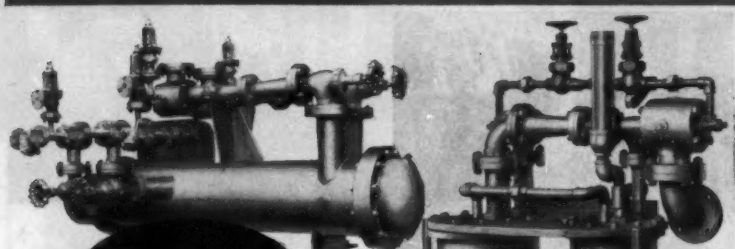
Boston, Mass.	Havana, Cuba	Richmond, Va.
Buffalo, N. Y.	Houston, Tex.	Roanoke, Va.
Chicago, Ill.	Kansas City, Mo.	San Francisco, Calif.
Cincinnati, O.	Los Angeles, Calif.	Seattle, Wash.
Cleveland, O.	Mexico D.F., Mexico	St. Louis, Mo.
Coral Gables, Fla.	Minneapolis, Minn.	Toronto, Ont.
Denver, Colo.	Mobile, Ala.	Tulsa, Okla.



GRAHAM MANUFACTURING CO., INC.

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What's Happening . . .

face Area—Adsorption Measurements by a Continuous Flow Method," F. M. Nelsen and F. T. Eggertsen, Shell Development Co., Emeryville, Calif. "A Simple Light-Absorption Meter for the Estimation of Material Insoluble in Used Lubricating Oils," F. S. Alvey and R. L. Martin, British Petroleum Co., Ltd., Sunbury-on-Thames, England. "Determination of Bromine Numbers with Electrically Generated Bromine and Spectrophometric Detection of the End Point," John W. Miller, M. D. Grimes, and B. J. Heinrich, Phillips Petroleum Co., Bartlesville. "The Variable Influence of Automotive Fuel Type on Exhaust Composition," R. W. Hurn, Bureau of Mines, Bartlesville. "Quantitative Determination of Platinum in an Alumina-Base Reforming Catalyst by X-Ray Spectroscopy," Arnold J. Lincoln, Baker and Co., Newark, N. J., and Edwin N. Davis, Sinclair Research Laboratories, Harvey, Ill.

TUESDAY, MAY 13, 1958

9:00 a.m. Processes

Presiding: H. Y. Hyde, Tidewater Oil Co., San Francisco.

Session developed by F. C. Moriarty, Aurora Gasoline Co., Detroit. "Bulk Acid Polymerization of Motor Gasoline," California Research Corp., San Francisco. "New Developments in Refining Petroleum," M. J. Sterba and Davis Read, Universal Oil Products Co., Des Plaines, Ill. "Catalytic Cracking Feed Preparation," M. V. Medlin, J. C. Ornea, and A. J. Johnson, Shell Development Co., Emeryville, Calif.

9:00 a.m. Fuels

Presiding: A. L. Lyman, California Research Corp., San Francisco.

Session developed by J. F. Socolofsky, Socony Mobil Oil Co., Inc., Paulsboro, N. J. "The Role of Physical Factors in Knock," Ellis B. Rifkin, Ethyl Corp., Detroit. "Studies of the Chemical Reactions Occurring in an Engine Prior to Knock," R. H. Blaker, A. J. Pahnke and K. J. Pipenberg, E. I. du Pont de Nemours and Co., Inc., Wilmington, Del. "Knock Characteristics of Hydrocarbon Mixtures," Eric J. Y. Scott, Socony Mobil Oil Co., Inc., Paulsboro, N. J., Chairman of the Subcommittee on Rating of Hydrocarbon Mixtures of API Project 45.

2:00 p.m. Pressure Vessels

Presiding: R. E. Lauterbach, General Petroleum Corp., Los Angeles.

Session developed by N. J. Rees, Socony Mobil Oil Co., Inc., New York. "Design of Skirt Supports for Pressure Vessels in High-Temperature Cyclical Service," D. B. Rossheim, The M. W. Kellogg Co., Jersey City, N. J. "Considerations Involved with the Possible Use of Increased Design Stresses for Pressure Vessels and Their Effect on Safety," George E. Fratcher and A. F. Cota, A. O. Smith Co., Milwaukee. "Survey of Brittle Characteristics of Carbon Steels Used for Pressure Vessels," F. B. Hamel, The Standard Oil Co. (Ohio), Cleveland. "Who Should Foot the Bill for Research and Development of New Steel Materials," C. L. Huston, Jr., Lukens Steel Co., Coatesville, Pa.

2:00 p.m. Training

Presiding: P. J. Merkus, Shell Oil Co., Wilmington, Calif.

Session developed by G. B. Stone, Union Oil Co. of California, Rodeo. "The Dimension of Knowledge Needed by Today's Management People," Laurence de Ryke, Occidental College, Los Angeles; Robert F. Smith, University of California at Los Angeles.

7:30 p.m. Processes

Presiding: Fred Powell, Standard Oil Co. of California, San Francisco.

Session developed by F. C. Moriarty, Aurora Gasoline Co., Detroit. "Improvement of Catalytic Cracking Feedstocks by Hydrogenation," M. D. Abbott, R. C. Archibald and R. W. Dorn, Shell Development Co., Emeryville, Calif. "Upgrading Distillate Stocks by Unifining," C. F. Gerald and L. O. Stine, Universal Oil Products Co., Des Plaines, Ill.

WEDNESDAY, MAY 14, 1958

9:00 a.m. Air Pollution

Presiding: David E. Day, Richfield Oil Corp., Los Angeles.

Session developed by C. A. Jones, Shell Oil Co., Wilmington, Calif. "Investigations to Detect the Atmospheric Conversion of Sulfur Dioxide to Sulfur Trioxide," Albert L. Chaney, Albert L. Chaney Chemical Laboratory, Glendale, Calif. "The Effect of Organic Materials in the Atmosphere on Vegetation," John Middleton and Ellis Darley, University of California, Riverside, Calif., and E. R. Stephens, The Franklin Institute, Philadelphia. "Effect of Operating Variables on Automobile Exhaust Gas Composition," C. M. Heinen, Chrysler Corp., et al.

2:00 p.m. Waste Disposal

Presiding: K. E. Kingman, Union Oil Co. of California, Los Angeles.

Session developed by J. H. Easthagen, California Research Corp., Richmond. "Pollution Control at

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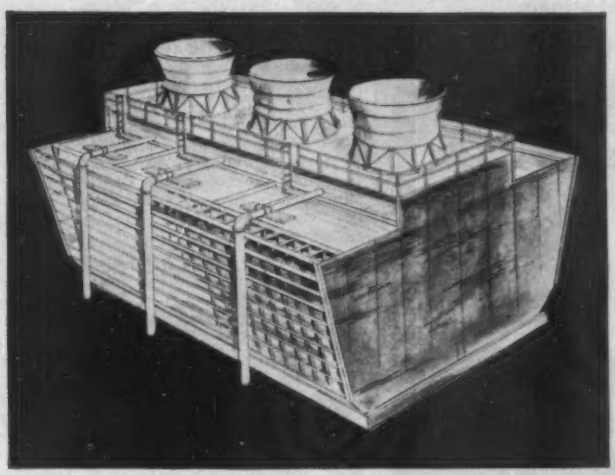
A new slant on Industrial Cooling Towers



MARLEY *Class 600* Double-Flow

NEW IN PROFILE—NEW IN PERFORMANCE. These characteristic advances announce a forward trend in cooling towers and introduce the new Marley Class 600 Double-Flow and Single-Flow models. They embody design improvements that are seven-league strides in water cooling practice and achievement. • • • The new profile is completely functional. It is the basis of many fundamental changes that mean increased cooling capacity in every frame size with greater power economy and no additional basin cost. Class 600 Cross-Flows have more filling and the ability to keep more water in the fill area; to reduce direct, unbroken water fall. The fill is of uniform width at all elevations, exposing the water to equalized air flow at all points of the cooling chamber. • • • From the new wide louvered walls to the fan, air flow is cleared of obstructing elements. Pressure control and air discharge are more proficient. This lowered draft loss efficiently balances increased water capacity in Class 600 Cross-Flows. • • • The angled louver walls make possible simple controls that facilitate winter operation in areas where icing is a problem. • • • In Class 600 Cross-Flows extended durability—increased resistance to corrosion—keeps pace with stepped-up cooling ability. They are the first standard models completely asbestos cement board encased, and they introduce inert materials for use throughout the structure. • • • These towers establish a quality standard new to water cooling equipment and of importance to you as an investor. You can get all detailed information from the nearest Marley engineer in 56 major cities or by writing direct.

Protected by patents pending

The Marley Company

Kansas City, Missouri

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What's Happening. . .

Ferndale, Washington," E. K. Daniels, L. A. Castler and J. R. Lutz, General Petroleum Corp., Los Angeles. "Waste Disposal Facilities at the Anacortes Refinery," Shell Oil Co. "The Design of Smokeless Non-luminous Flares," P. D. Miller, Jr., and H. J. Hibshman, Esso Research and Engineering Co., Linden, N. J., and J. R. Connell, Imperial Oil, Ltd., Sarnia, Ont., Canada.

7:00 p.m. Dinner

Presiding: H. W. Ferguson, Vice President for Refining, American Petroleum Institute; Humble Oil and Refining Company, Houston.

Session developed by David E. Day, Richfield Oil Corp., Los Angeles.

New Catalyst Firm Formed

Formation of a new corporation has been announced by Charles W. Engelhard, New Jersey industrialist. Named Engelhard Industries, Inc., it was formed by a consolidation of nine American companies in the precious metals and precision-manufacturing fields, some of them over 50 years old. Three other domestic companies and twelve foreign corporations also are controlled by the same interests.

Described as diversified industrial entity which serves, directly or indirectly, every major industry in the United States, it includes the production of platinum catalyst for processing in the petroleum and petrochemical industry.

Plant Layoffs Continue

Four more companies announced last month that they were in the process of laying off plant employes.

At the Bayonne Refinery of Esso Standard Oil Co., 700 workers were laid off. Dr. D. F. Edwards, plant manager, said at a press conference that the layoff is necessary because the plant's rebuilding program had reached the point where "we no longer have work for these people." He said the Refinery would do "everything possible to help these employes find other work and has proposed liberal layoff allowances to tide them over while they find other employment."

Edwards said that about two-thirds of the plant's current force of 1650 had been engaged in construction work as part of a rebuilding program. Esso has been rebuilding its Bayonne plant for the past four years.

At Toledo, The Pure Oil Co. laid off 106 of the 535 employes at its 38,000 bpd refinery. A refinery management spokesman said the layoff was a direct result of shutdown of two units, an alkylation plant and No. 1 combination high pressure crude unit.

The former ceased production as the result of the termination of a government alkylation contract. The latter was shut down to bring production in line with current demand.

The third company, Dow Chemical, had previously laid off 300 men at Freeport, Texas, and were to have laid off 500 more due to lagging magnesium sales. Although some of the employes were shifted to other departments, about 800 jobs altogether have been affected.

The only other refinery which definitely announced layoffs was the Texas City refinery of American Oil Co., where one man per shift per unit will be cut until a 150-man reduction is achieved.

Other major Gulf Coast refiners have no definite plans for labor reductions, but most indicated that their hiring programs for the year are far below normal.

Runway Test in August

Army engineers told House Services Investigating subcommittee that the test for adequacy of asphalt runways may not be completed until August 1.

Bad weather has delayed the completion date, originally set for April 1, said Brig. Gen. Edward A. Brown, Army Engineers. Warmer weather at a later date will increase the testing date from the planned one month to about ten weeks, he added.

Maximum weight load has been increased from 265,000 pounds weight of the B-52 bomber from the original 240,000 pounds.

John Ferry, special assistant on installations to the Air Force Secretary, said that the use of asphalt in future runways will depend on the outcome of the tests. He said the Air Force is now contracting only for concrete runways.

Octanes Still Hold Steady

Gasoline on sale at service stations in January showed national weighted averages of 98.4 octane number for premium and 91.0 octane number for regular, according to the latest monthly survey of antiknock quality compiled by Ethyl Corp.

The premium gasoline average was unchanged from December but 1.0 octane

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Struthers Wells

FIRED HEATERS

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DIRECT HEATING
of hydrocarbon oils, gases, for gas cracking, steam superheating and many other services.

INDIRECT HEATING
using Dowtherm, Aroclor, heat transfer oil, liquid metals and other heat transfer mediums.

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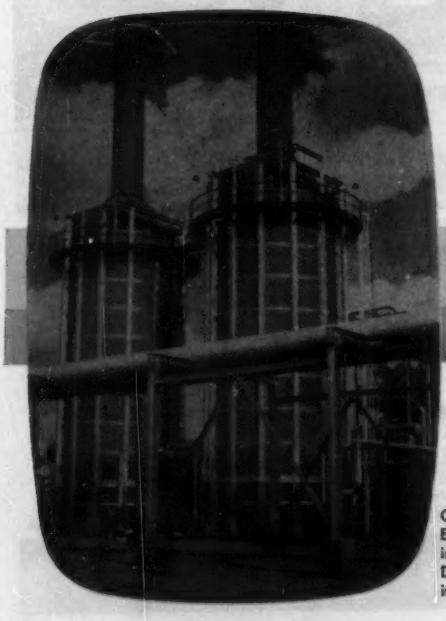

The photos show two tar separator heaters installed at a new refinery in Mississippi. These heaters are provided with alloy tubes, capacity 54,000,000 BTU per hour each. A total of seven Struthers Wells fired heaters were installed in this plant.

Struthers Wells supplies high-temperature heating equipment for a wide variety of services and industries. Temperatures range to above 1650°F. Struthers Wells heaters are characterized by trouble-free operation, long life and high thermal efficiencies. Hundreds of installations throughout the U.S. and some 15 foreign countries indicate the universal acceptance of Struthers Wells fired heaters.

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FORGE DIVISION
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number higher than a year ago. The regular gasoline average was 0.1 octane number lower than December but 0.5 octane number higher than a year ago.

For companies marketing more than one grade of premium, the survey showed a range of 100.6 to 102.4 octane number for the highest grade, on the basis of 37 samples in 20 cities.

OCAW Eyes Major Gains

Late this month, from the 22-23, the bargaining policy committee of the Oil, Chemical, and Atomic Workers Union will meet in Denver, to consider a "militant and aggressive program to bring about vast improvements in terms and conditions of work."

In announcing the meeting, OCAW president, O. A. Knight said, "We intend to recommend some short-range goals, including an improvement in the wage situation and we also plan to recommend a long-range program of major improvements suitable to a militant, aggressive fighting membership."

Knight was quoted as telling his staff that "better sick leave and health insurance" is one of the major needs of oil and chemical workers. He also discussed the idea of a royalty on physical production in the various industries—with the royalties collected to be prorated to the account of each individual wage earner concerned.

On the subject of pensions, Knight asserted that the practice of a company nicking the employes for half of the cost of a pension plan was an antiquated system and should be replaced by pensions fully paid for by the companies.

Most of OCAW's 600-odd contracts in the oil industry will be opened for negotiations in late spring and early summer.

Ethyl Granted New Patent

Ethyl Corp. reports a patent coverage has been obtained on the new anti-knock compound for gasoline announced by the company last June and currently being tested by numerous oil companies.

The experimental anti-knock agent is an organic compound of manganese. The patents cover chemicals in which a cyclopentadienyl group is attached to a metal which is also attached to other organic and inorganic groups. The specific anti-knock which Ethyl is making available to oil companies for their evaluation is a derivative of cyclopentadienyl manganese carbonyl.

Greeks to Run Refinery

Socony Mobil Oil Co., Inc., has confirmed reports from Greece of the award by the Greek government of a 10-year lease of its newly completed refinery to a private Greek company in which Socony has an interest. This company was formed by two prominent Greek businessmen, Bodosakis Athanassiades and Stavros Niarchos, and Socony Mobil for the purpose of leasing the new refinery.

Under the leasing arrangement, Socony Mobil has undertaken certain commit-

Worcester's New Econ-O-"Miser" Ball Valve* is BOTH

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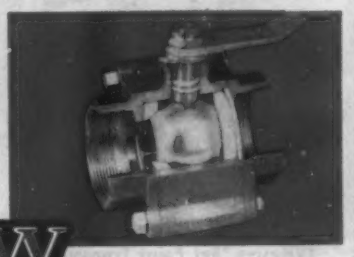
This great new advance in valve design can mean substantial savings for you. Its unique construction makes the Econ-O-"Miser" both ball valve and union in a line whether the application be original equipment, in-plant maintenance or process lines.

The costs of a union and installing it are eliminated, resulting in tremendous savings when the number of ordinary valves and unions in even a small installation is considered. Add to this the longer operating life of the Econ-O-"Miser", the time and materials savings of *in-line maintenance*, and you get performance unmatched by *any* valve at *any* price.



The Econ-O-"Miser" is available in Bronze, Aluminum, Aluminum Bronze, Forged Carbon Steel, Stainless Steel types 303 and 316. Seat and seal materials available: Teflon, Buna-N and Neoprene (others available on request.)

The many combinations of body and seat seal materials allow handling of exceptionally wide range of media.

Other Outstanding Features

- Compact for ease of installation
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- **In-line maintenance** permits quick, easy inexpensive repairs
- Two-way flow allows application of pressure or vacuum to either side of valve
- Quarter turn operation — readily adaptable to remote control
- Visual determination of OPEN — CLOSED positions — No manual check needed
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- "Wiper-action" of resilient seat against ball eliminates abrasive wear due to foreign materials in media . . . assures leak-proof seal . . . long operating life

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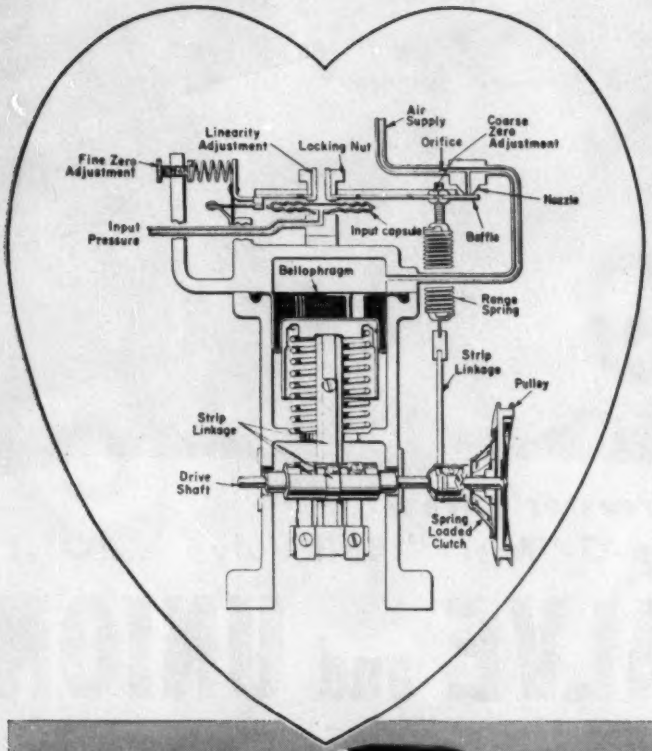

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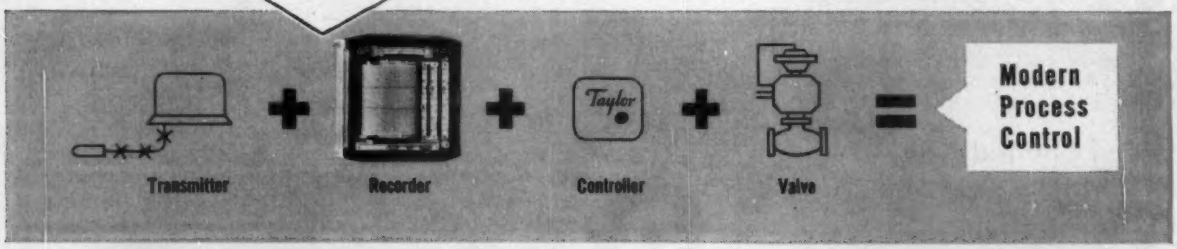
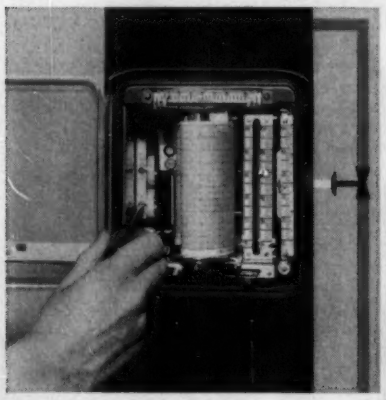
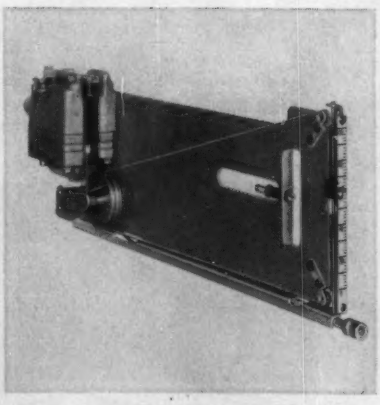
0.1% THRESHOLD SENSITIVITY—A NEW STANDARD OF ACCURACY. Responsiveness to transmitter output is 0.1%; and because of the very small pneumatic displacement of the input capsule, the response is practically instantaneous. You see more minute process changes, enabling you to make optimum control settings to increase yield of specification product. All servos are identical and interchangeable. Servo-pen connection is by means of cable . . . no long, jointed, flimsy links or levers. Allows perfect linear conversion from rotary motion . . . repeatability is truly amazing.

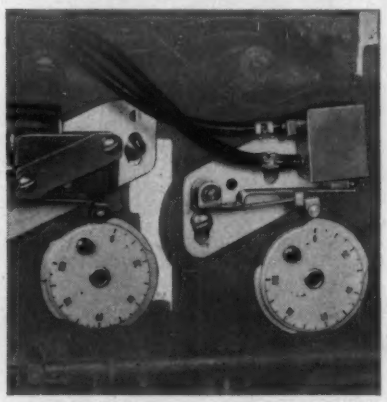




Controller Settings are made from the front while recording. Gain, reset and PRE-ACT* dials are calibrated in specific units. Eliminates blind adjustments; settings and results are seen in one-spot . . . the front of the panel.



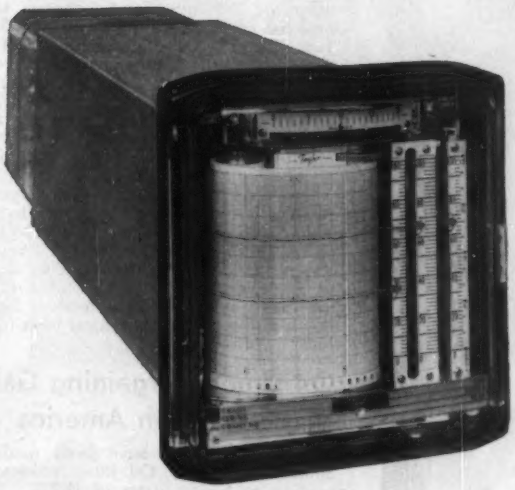
Exclusive "Set Point Transmitter" allows continuous automatic control during recorder removal. Plug-in transmitter assembly may be removed and control valve sealed in operating position. Perfect for continuous processes.



Optional Alarms. Each SERVOMATIC motor can operate either an electric or a pneumatic alarm. Each alarm can be adjusted for one high and one low, or two high, or two low operating points. Microswitch on left, air valve on right.

Recorder brings you . . .

REVOLUTIONARY ACCURACY, BIG-INSTRUMENT FEATURES



"No other recorder, regardless of size, puts so many features in so little panel space."

Front of Panel Control Settings let you make adjustments easier, quicker, and better . . . *from the front of the panel* . . . while recording! You can clearly see what you are doing, and the results, because the record is continuous.

Stays on Automatic Control while the recorder is removed for inspection. The unique Set Point Transmitter remains plugged in the case, providing continuous fully automatic control.

Complete Indicating Control Station while recorder is removed. You see the variable. There's no need to shut down the process for instrument service or adjustments. Horizontal gage at top of recorder will show either process variable or air output to valve, as desired.

Receives Three Variables to be recorded or indicated; has a Set Point Transmitter, an Automatic-to-Manual switching lever, a Cascade or process-output indicator, and many other features . . . all in a compact case.

For further information about this revolutionary new recorder, see your Taylor Field Engineer, or write for **Form No. 98282.** Taylor Instrument Companies, Rochester 1, N. Y., or Toronto, Ontario.

*Trade-Mark

MADE FOR EACH OTHER!

The Taylor TRANSCOPE Controller and Recorder are companion instruments. Together they give you new standards of process control performance . . unprecedented accuracy and adaptability.

Ideal for the time constants of modern processing, exceptionally fast and responsive to adjustments, the TRANSCOPE Controller is also highly adaptable and simple to maintain. Write for **Bulletin 98278.**

Taylor Instruments

— MEAN —

ACCURACY FIRST

VISION · INGENUITY · DEPENDABILITY

For more data on advertised products, use Readers' Service Cards, last page.

Custom Fabricators of Petroleum Processing Equipment
Whether your fabricating requirements call for a tower, a complicated stainless steel vessel, or a giant storage tank, C.S.T. can handle it.
When you need fabricated vessels and process equipment, Chicago Steel Tank Company, with its facilities, know-how, and experience, can meet your most rigid requirements and code specifications. Call a C.S.T. sales engineer today.
Write for your personal copy of the C.S.T. facilities booklet.
Custom Fabricators and erectors since 1899
CHICAGO STEEL TANK COMPANY
division of U.S. INDUSTRIES, INC.
SALES OFFICES: 6400 W. 66TH STREET • CHICAGO 38, ILLINOIS • PO-7-8900
51 E. 42ND STREET • NEW YORK, N. Y. • MU-7-9298

What's Happening. . .

ments with regard to the supply of crude oil for the refinery.

The rated capacity of the refinery, at Aspropyrgos, a few miles outside Athens, is 27,000 bpd. Equipment includes a crude distillation unit and a catalytic reformer for production of high-octane gasoline. The refinery is expected to supply most of the requirements of all major products in Greece except aviation gasoline and lubricants, which it will not manufacture at all.

Exhibition to Draw 75,000

Over three-quarters of a million square feet of display space will be used by a thousand exhibitors at the 12th Chemical Engineering Exhibition and Congress to be held in Frankfurt, Germany, May 31 to June 8, 1958. A technical program of 232 papers has been arranged under the auspices of societies representing 18 different countries. The 1955 registration of over 75,000 visitors is expected to be surpassed in 1958, as over 4000 visitors from 50 different countries had completed preliminary registration by November 1957.

The technical program will begin in Brussels on May 28, with plenary lectures arranged by the Belgium member societies of the European Federation of Chemical Engineering. Visits to the World's Fair will be made, and after two days of meetings, the group will travel to Frankfurt for the Exposition and other technical meetings.

Oil Union Bargaining Gains Made in South America

Bargaining gains have been made in South America by Oil labor unions, according to headquarters of IFPW.

The final contract was signed by Petroleum Workers Federation of Curacao with Shell Oil. About 8500 workers are covered by the contract from Dec. 1, 1957-May 31, 1960, which provides wage increases of five percent and seven percent and a bonus of one and one-half weeks pay in lieu of retroactivity. This is equivalent to a 4.5 percent wage increase from April.

Wage increases from 12 percent to 25 percent have been granted by oil companies in new agreements with the Petroleum Federation of Colombia, and IFPW affiliate. The new agreements cover 7500 workers with subsidiaries of Jersey Standard, Shell, Texaco, and Impresa Colombiana.

Negotiations have begun with the "Federation" and Colombia Petroleum Co. to reduce the work week from 44 and 48 hours to 40 hours. IFPW contracts just signed provide for a 44-hour week.

Kellogg Offers New Process

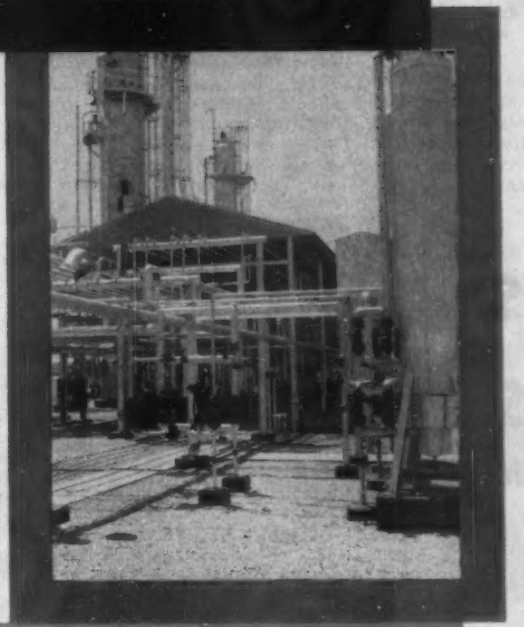
A process for the continuous production of acetylene and ethylene from naphtha or natural gas feedstocks is now offered by The M. W. Kellogg Co., New York, a subsidiary of Pullman Inc. The process was originally developed by Societe Belge de l'Azote (SBA), Liege, Belgium.

Using naphtha as feedstock, a wide range of ethylene to acetylene ratios may be produced and the flexibility of the process makes possible the simultaneous production of ethylene and acetylene. When natural gas is used as feed, acety-

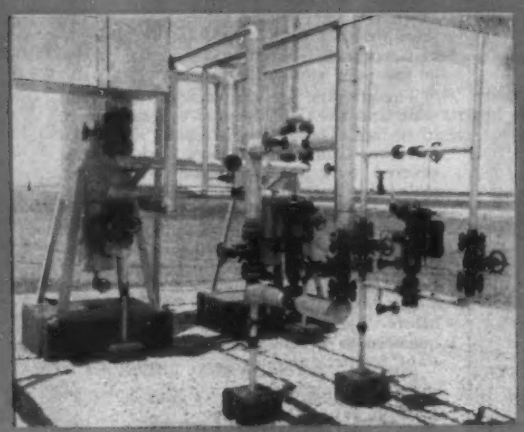
For more data on advertised products, use Readers' Service Cards, last page.

start using orbit

forged steel asa class valves in your process area from formation to finished product



Right foreground, propane dehydrators. In background, plant process pump area.



ORBIT FORGED STEEL ASA CLASS VALVES IN SERVICE AT A KANSAS GASOLINE PLANT.

Propane dehydrators.

Product loadout pumps and storage area.

advantages

No voids or cavities in body or bonnet where pressures can build up from trapped fluids when valve is either in open or closed position.

Non-lubricated, positive, friction-free closure which eliminates possibility of product contamination from valve lubricants.

Rising stem.

Adjustable, pliable stem packing.

All forged steel, vapor-tight construction.

ORBIT ASA CLASS VALVES are available in Carbon or Stainless Trim. Full Round Opening Sizes 1" thru 4". Ratings: 300 lbs. thru 2500 lbs. Flanged or Screw Ends. Venturi Opening Sizes 2" thru 6". Ratings: 150 lbs. thru 2500 lbs. Flanged End Only.

AVAILABLE THRU YOUR FAVORITE OIL FIELD SUPPLY STORE OR REFINERY SUPPLY HOUSE

ORBIT VALVES®

ORBIT VALVE COMPANY

BOX 699, LUther 4-4761, TWX TU 925 TULSA, OKLAHOMA

WAREHOUSES: HOUSTON, TEXAS, 407 Velasco, CApitol 8-6623, TWX HO 115; ODESSA, TEXAS, 402 West County Road, FEderal 7-2263, TWX ODESSA TEX 8041; EDMONTON, ALBERTA, CANADA, 7119-104th Street, Phone 391-283

WEST COAST REPRESENTATIVE: Fred P. Koenig Company, Long Beach, Calif., 3815 Atlantic Avenue, GArfield 4-3834

CANADIAN REPRESENTATIVE: T. R. Pickford & Company, Ltd., Calgary, Alberta, 536 8th Avenue West, Phone 2-7371

EXPORT REPRESENTATIVE: New York 36, N. Y., 500 Fifth Avenue, BRyant 9-2236

What's Happening. . .

lene is the primary product and negligible quantities of heavy impurities are encountered. The SBA-Kellogg process can be designed to operate on either feedstock.

In the process train, the heavy acetylene and hydrocarbons are separated first, leaving a stream containing acetylene and lighter materials. By using an SBA-developed ammonia absorption system, acetylene is removed from lighter materials comprised essentially of ethylene, hydrogen and carbon monoxide, valuable by-products in themselves. The acetylene, 99.5 percent pure or higher, is then stripped from the ammonia.

Shell Fellowships Increased

Shell Companies Foundation, Inc. announced that fellowships will be provided for special study next summer to 100 high school teachers of physics, chemistry and mathematics.

This is a 67 percent increase in the size of the Foundation's Merit Fellowship program since the first 60 fellowships were awarded in 1956. There were 90 fellowships last year.

The Foundation said the program is designed to help check the nation's shortage of scientists by strengthening the teaching of high school chemistry, physics and mathematics and thus encouraging more young people to plan scientific careers.

Chemicals Causing Floor Failures?

Here's An Invitation to Consider . . .

When designing or replacing floors for CHEMICALLY CRITICAL AREAS!

* High Impact Resistance and Load Bearing Strength
* No Water in Mix Design
* Devran Epoxy Resin Binder Protects Against Chemical Attack
* Saves Repeated Shutdowns
* Positive Bond—No Mortar Joints
* Saves Structural Floor Base
* Placed Like Regular Concrete (Not a Skim Coat)
* Optimum Thickness ½ inch

A request on your letterhead stating your floor corrosion problem will be followed by a personal inspection and specification by a qualified Truscon representative.

TRUSCON
Industrial Maintenance Division of Devoe & Raynolds Co., Inc.
Laboratories
Detroit 11, Michigan

Britain to Hold Exhibition

Britain's first chemical and petroleum engineering exhibition, sponsored by the British Chemical Plant Manufacturers Association and the Council of British Manufacturers of Petroleum Equipment, is being held at Olympia, June 18-28, 1958.

About 250 exhibitor manufacturers have booked stands, and their exhibits cover 125,000 square feet—occupying Olympia's two largest halls and galleries.

Plant, equipment and ancillary services offered by the exhibitors will cover nearly 1000 product classifications.

During the exhibition The Institution of Chemical Engineers, in conjunction with The Institute of Petroleum, will stage a symposium on "The Organization of Chemical Engineering Projects," and papers will be presented at four sessions spread over three days. This symposium will also form part of the 1958 program of the European Federation of Chemical Engineering.

Ice Storage Improves Gas

Aviation gasoline improves when stored in pits carved out of ice in the tunnel which the U. S. Army Corps of Engineers has driven into the Arctic Icecap to a distance of nearly 1200 feet, the Department of the Army has announced.

The fuel, which evaporates rapidly and takes on other impurities under normal climatic conditions, can be stored indefinitely in the pits under the icecap, according to scientists employed by the Snow, Ice and Permafrost Research Establishment, Wilmette, Ill., a Corps of Engineers laboratory. The scientists have determined that the fuel not only retains all of is properties but is even improved after an extended storage period.

The gasoline was put into pits four feet wide and five feet deep at several points in the ice. These pits are from 150 to 400 feet back from the entrance. Each pit was covered only with plywood board and sealed by ice slush when the Engineers suspended work on the Icecap in the fall of 1956. When work was resumed in the Arctic in the spring of 1957, scientists found the fuel, none of which had evaporated, in even better condition than it had been when placed in the pits seven months before. They said the fuel contained less moisture as a result of the low and constant temperatures.

Changing Times

Phillips Petroleum has announced plans for the formation of Astrodyne, Inc., **a company to specialize in the missile rocket power field.** The new company is to be jointly owned by Phillips and North American Aviation, Inc., who will **unite their activities in the expanding field of solid propellants** for rocket engines and aeronautical power units.

Gladewater Refining **has closed its 2500 bpd refinery** at Gladewater, Texas, because there is "just too much gasoline around."

Another new company, this time in Europe, has been formed by Goodrich Chemical Co., Cleveland, and Algemene Kunst-

For more data on advertised products, use Readers' Service Cards, last page.

Installing 15,000-volt Loxarmor feeder (above). Single pulls as long as 1,600 feet were made around corners (right) without re-sorting to splices. A half-inch stainless steel messenger was used.

15kv Loxarmor® aerial feeders replace bare wires at refinery

In replacing bare wire aerial feeders that had proved unreliable in bad weather and had, on several occasions, shorted out and burned down, a Texas refinery installed nearly 8,000 feet of Okonite oil-impregnated, paper-insulated, lead-sheathed Loxarmor cable. Protected with an interlocking S-shaped bronze armor (Loxarmor), this cable has proved itself 100% reliable. The Loxarmor provides mechanical protection against movable drag lines, cranes, and the like.

Here is one example of how industry uses versatile Loxarmor cable—the modern conduit-type cable that's mechanically strong, flexible and versatile. For either power or control circuits, Loxarmor cable has proved itself time and again to be economical . . . easy to install indoors or outdoors . . . easy to move and re-route . . . easy to inspect and maintain . . . completely reliable and dependable.

Loxarmor can be supplied over any standard Okonite insulation, rubber, plastic, paper or varnished cambric—depending upon your installation conditions and voltage requirements. It is available in galvanized or stainless steel, aluminum or bronze. For full details, contact your local Okonite representative or write to The Okonite Company, Passaic, New Jersey.

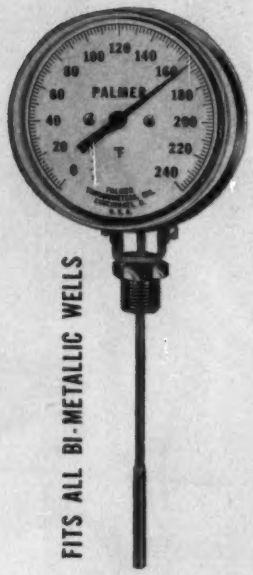
where there's electrical power... there's **OKONITE CABLE**

4845

Outstanding Accuracy

PALMER

Dial Thermometer



Check these functional features

- Direct-drive Bourdon Coil with a filled system for longer lasting accuracy.
- Stem can be placed at any desired angle and case can be rotated to most readable position.
- External calibration for zero setting.
- Unaffected by stem alignment.
- Accurate to one scale division.
- No sticking at any temperature.
- Non-corrosive case.

PALMER

THERMOMETERS, INC.

Mfrs. of Industrial Laboratory, Recording and Dial Thermometers

2515 Norwood Ave., Cincinnati 12, O.

What's Happening. . .

zijde Unie N. V., Arnhem, Holland. New firm will construct plant at Arnhem and **will manufacture special purpose man-made rubber.**

Small business certificates issued to refiners have been extended to March 31, unless sooner revoked. It is intended that prior to that time a new refiner small business definition will be adopted for use in government procurement. **New definition** will probably call refiners "small business" which, together with affiliates, have less than 500 employes and less than 20,000 bpd capacity.

Several changes of address were announced last month. **In Chicago:** UOP now has its branch office in Suite 2061 of the McCormick Building. **In New York:** Foster Wheeler has moved its employes to 666 Fifth Avenue.

D-X Sunray refinery employes have refused union representation in a recent election conducted by the National Labor Relations board at the West Tulsa plant. Ballot offered eligible refinery voters three choices. **Final vote: 538 for no union; 501 for OCAW; 24 for Operating Engineers Union.**

Foster Wheeler and Ishikawajima Heavy Industries, Inc., Ltd., Tokyo, have formed new Japanese firm known as Ishikawajima Foster Wheeler Co., Ltd. New firm will sell, design, engineer, and construct refineries and petrochemical plants.

American Gilsonite is testing **road surfacing which can be laid cold, even below 35 F.** (cutoff point for spreading hot-mix asphalt). Possibility that it may be on the market soon at a price competitive to current asphalt prices.

Within the year, Esso's Bayway refinery expects to ready its **huge underground caverns for storing under pressure, up to 28 million gallons of liquefied propane and butane.** The gas, used mostly in rural areas for heating and cooking, will be piped to the surface and syphoned into special delivery trucks as needed.

Japan Petroleum Co. has received **query from Red China for about 300,000 barrels per month of fuel oil** for shipment to that country. Japanese firm is reportedly interested and may **try to get ban lifted** on such exports to Communist China.

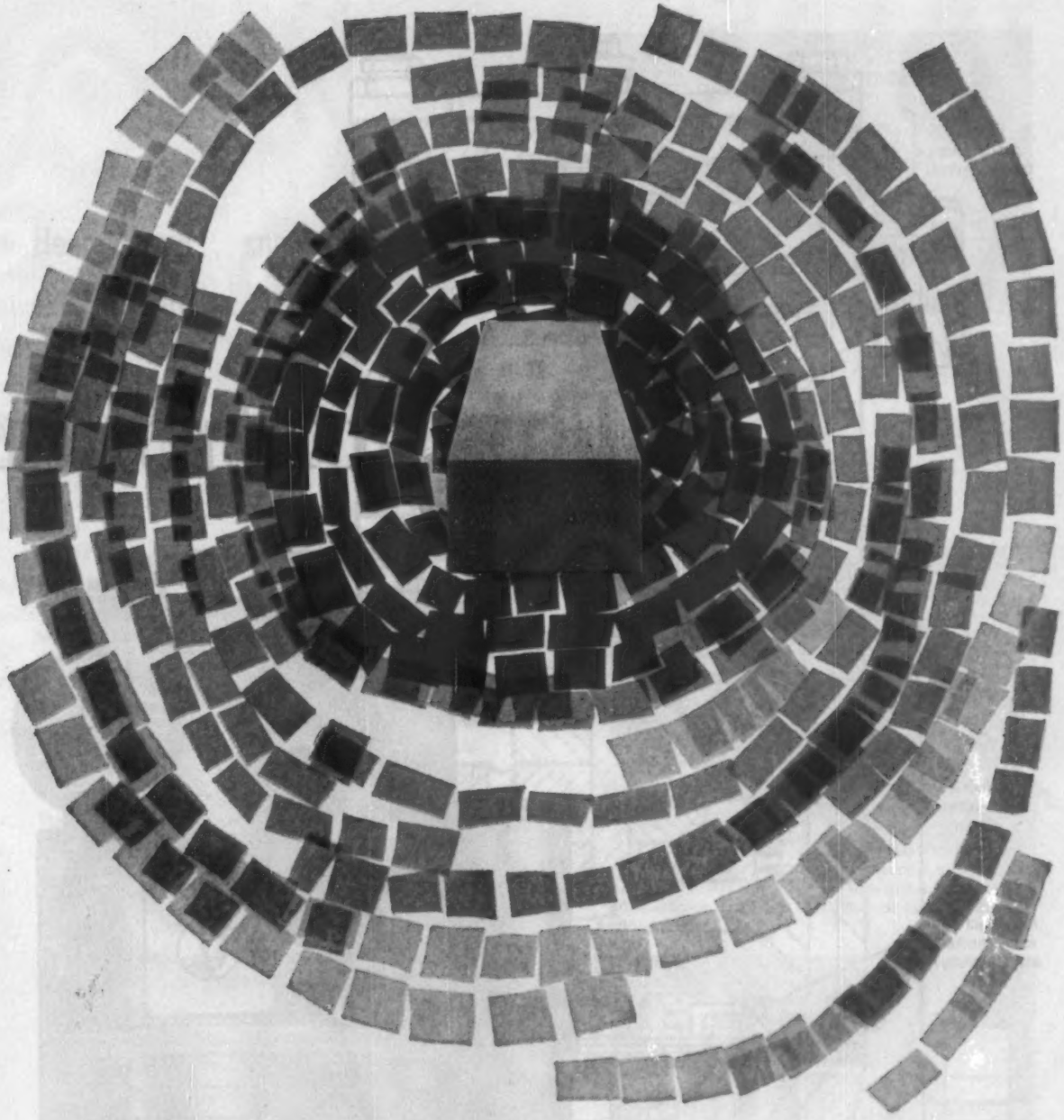
Union Oil Co. of California has protested bids received by Military Petroleum Supply Agency from Aurora, Shamrock and Cosden as "small business" firms.

California Standard has undertaken a new traffic safety education program. During last December, the **company sponsored safe driving messages on some 500 outdoor display boards**—will do the same next July.

MEETINGS CALENDAR

1958	
FEB.	
16–20	Society of Petroleum Engineers of American Institute of Mining, Metallurgical, and Petroleum Engineers, Annual Meeting, Statler Hotel, New York.
27–28	API Division of Marketing, Lubrication Committee Meeting, Sheraton-Cadillac Hotel, Detroit.
MAR.	
2– 6	ASME Gas Turbine Power Conference & Exhibit, Shoreham Hotel, Washington, D.C.
3– 4	Society of Petroleum Engineers of AIME, 4th Annual Joint Meeting, Cosmopolitan Hotel, Denver.
5– 7	API Oil Information Committee, St. Francis Hotel, San Francisco.
13–14	Heat Transfer Technical Conference, Oklahoma State University, Stillwater.
16–22	ASME Nuclear Congress (Coordinated by Engineers Joint Council), International Ampitheater, Chicago.
17–21	Fourth Nuclear Engineering and Science Conference, Chicago International Amphitheatre.
17–21	National Association of Corrosion Engineers, National Meeting, Civic Auditorium, San Francisco.
19–20	ASME Engineering Management Conference, Somerset Hotel, Boston.
24–26	Western Petroleum Refiners Association, 46th Annual Meeting, Hilton Hotel, San Antonio, Texas.
26–28	American Power Conference, 20th Annual Meeting, Hotel Sherman, Chicago.
APRIL	
1– 3	ASME Instruments and Regulators Conference, University of Delaware, Newark, Del.
13–18	American Chemical Society, 133rd National Meeting, San Francisco, Site Unreported.
1–15	ASME Maintenance & Plant Engineering Conference, Penn-Sheraton Hotel, Pittsburgh.
14–17	ASME Design Engineering Conference, International Amphitheater, Chicago.
14–18	American Welding Society, Annual Technical Meeting and Show, Hotel Statler, St. Louis, Mo.
15–17	Southwestern Gas Measurement Short Course, University of Oklahoma.
17–18	Society of Petroleum Engineers of AIME, La.-Ark., East Texas and Miss. Petroleum Sections, Gas Technology Symposium, Site Unreported.
20–23	American Institute of Chemical Engineers, Montreal, Canada.
22–24	American Society of Lubrication Engineers Annual Meeting, Cleveland, Site Unreported.
24–25	ASME Management—SAM Conference, Statler Hotel, New York.
27–29	Independent Petroleum Association of America, Mid-year Meeting, Hotel Sherman, Chicago.
MAY	
5– 7	Purdue Industrial Waste Conference, Purdue University Memorial Union Building, Lafayette, Ind.
5– 9	API Safety and Fire Protection Committee, 11th Midyear Meeting, Cosmopolitan Hotel, Denver.
11–15	ASME Oil & Gas Power Conference & Exhibit, Bellevue-Stratford Hotel, Philadelphia.
12–14	Analysis Instrumentation Division of the Instrument Society of America, Annual Symposium, Shamrock Hilton Hotel, Houston.
12–15	API Division of Refining, Midyear Meeting, Statler Hotel, Los Angeles.
25–29	API Pollution Control Association, Annual Meeting, Sheraton Hotel, Philadelphia.
JUNE	
4– 6	American Petroleum Institute, Oil Information Committee Meeting, Sheraton Hotel, Chicago.
18–28	Chemical and Petroleum Engineering Exhibition, Olympia, England.
22–27	American Institute of Chemical Engineers, 50th Anniversary Meeting, Bellevue-Stratford Hotel, Philadelphia.

For more data on advertised products, use Readers' Service Cards, last page.



mix imagination with Alcoa Aluminas

and get refractories or refractory castables that work hardest, longest! Refractories are vital to production in almost every industry. To give industry the best refractories possible, more and more refractory manufacturers have turned to Alcoa® Aluminas. They've found that refractoriness and durability increase in direct proportion to the amount of alumina they use. They know it pays to mix imagination and engineering with Alcoa Aluminas . . . for the best in refractory performance at reasonable cost.

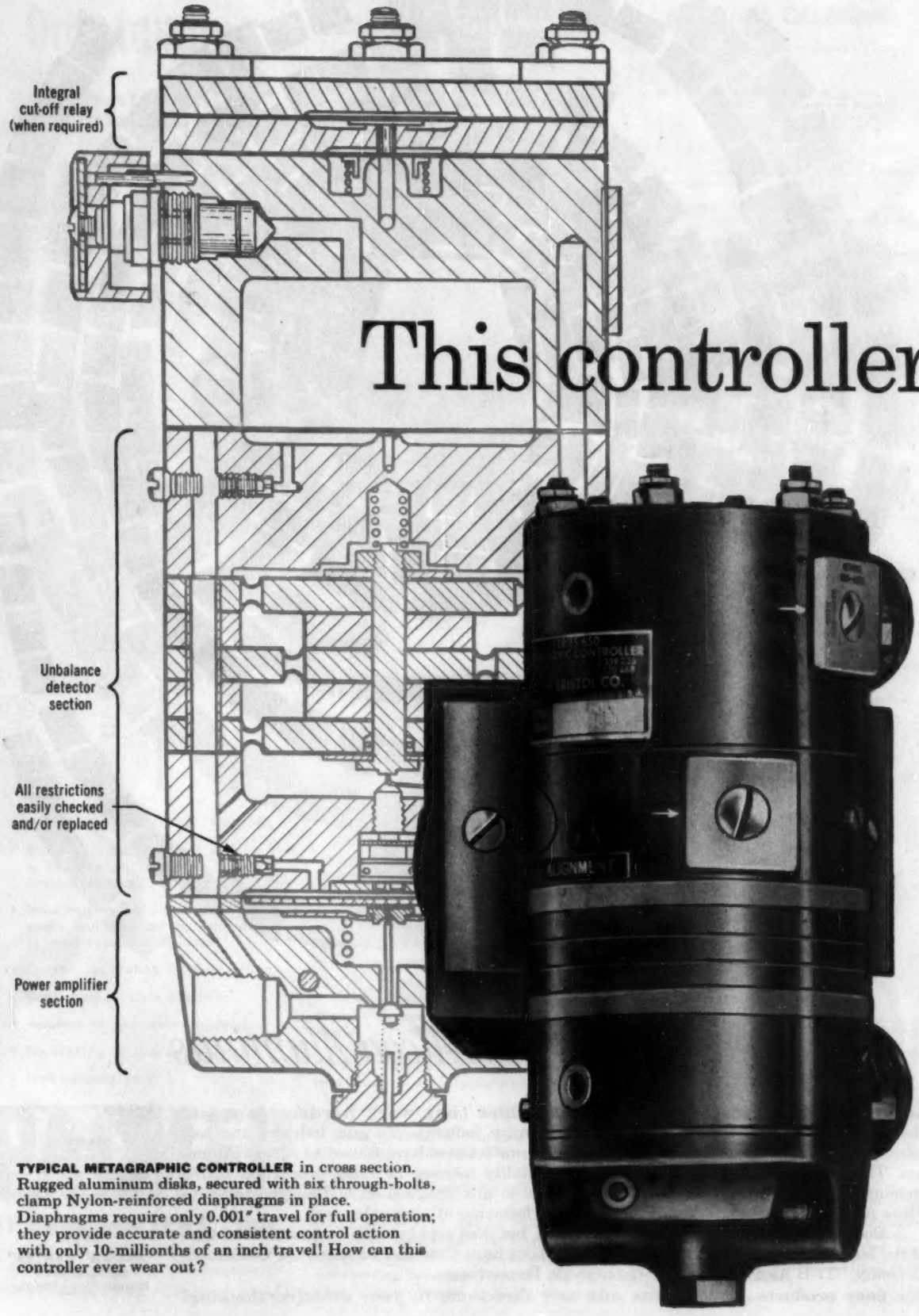
Alcoa is not a source for finished refractories, but does supply aluminas to manufacturers of the best refractories. For their names, write: ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 717-B Alcoa Building, Pittsburgh 19, Pennsylvania.

For finer products . . . let Alcoa add new directions to your creative thinking!

ALCOA CHEMICALS

"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

For more data on advertised products, use Readers' Service Cards, last page.


Integral cut-off relay (when required)
Unbalance detector section
All restrictions easily checked and/or replaced
Power amplifier section

This controller

TYPICAL METAGRAPHIC CONTROLLER in cross section. Rugged aluminum disks, secured with six through-bolts, clamp Nylon-reinforced diaphragms in place. Diaphragms require only 0.001″ travel for full operation; they provide accurate and consistent control action with only 10-millionths of an inch travel! How can this controller ever wear out?

FIVE MODES OF CONTROL

1 Fixed High-Gain (on-off)
2 Adjustable Gain Proportional
3 Proportional-plus-Reset
4 Fixed-Proportional plus Fast-Reset
5 Proportional-plus-Reset-plus-Derivative

Heat . . . rain . . . snow . . . ice . . .
overpressures . . . years of use . . .

stays on the job!

Operates from "universal" 3-15 psi pneumatic input signal . . . supplies precision pneumatic control of almost any variable

If your process needs a tough boss, here it is.

The Bristol Metagraphic Pneumatic Controller can take all the abuse either environment or process can hand out and still keep right on working. Its bolted, stack-type construction gives it practically the same durability as a solid metal cylinder. Its proved force-balance operating mechanism provides the most sensitive control in process handling, yet withstands overpressures of 100 psi on any connection. And check these features:

36 models to choose from.

Full plug-in service, where desired—With no loss of air pressure or disturbance to the indicating-recording action.

No bearings, no links, no levers—Operation is virtually motionless and frictionless.

High sensitivity—Only 0.01% change in input pressure produces measurable output change.

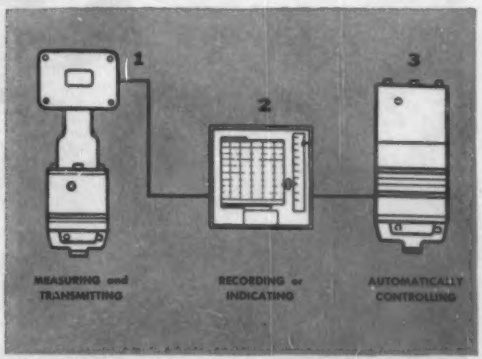
Wide ambient temperature limits—From −65° F to +225° F.

High output capacity—Up to 3 scfm on pipe connected models.

Low air consumption—Only 0.2 scfm when balanced.

Write for complete data on the Bristol Metagraphic Pneumatic Controller today. The Bristol Company, 111 Bristol Road, Waterbury 20, Conn. 7.50

FULL PLUG-IN FLEXIBILITY for receiver mounting or field mounting allows one-minute controller substitution with no disturbance to recording or indication.



HOW BRISTOL METAGRAPHIC CONTROLLER (3) fits into complete system. Controller may be located directly at controlled process or conveniently plugged into receiver (2).

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

you can meet any lubrication specification if you

BLEND WITH ENJAY PARANOX®

(DETERGENT-INHIBITOR ADDITIVES)

Blended with Paranox, lubricants can be compounded to combine *both* minimum wear and maximum engine cleanliness characteristics. That's why more and more refiners and blenders are relying *exclusively* on Paranox in formulating lubricants for heavy duty equipment and all engines that are subjected to tough operating conditions.

Through years of intensive research and development work with manufacturers and oil companies, Enjay has developed the only *complete line* of high quality additives (Paramins®) that can assure *maximum* performance characteristics. Why not let this experience and know-how work for *you*? Contact the Enjay Company today.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 WEST 51st ST., NEW YORK 19, N. Y.

Akron • Boston • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

What's Happening . . .

. . . *Among Men* in the Industry

Joseph M. Sexton has been named general manager of Societe Kellogg, the M. W. Kellogg Co.'s Paris subsidiary. Sexton was formerly manager of purchases at Societe Kellogg, a position he held since 1956 when the subsidiary was formed.

Sexton

Sexton joined M. W. Kellogg in 1942 as an inspection engineer. He advanced to the position of chief inspector and subsequently to manager of the inspection department. In 1950, he was appointed manager of plant purchases.

Sexton was transferred to Kellogg International Corp., London, in 1953 as manager of purchases.

Sexton is a graduate of Lehigh University. He holds a registered professional engineer's license in the United States and is a member of the ASME, NSPE, ASTM and NAPA in the U. S. He is Past Chairman of the Petroleum Division of the ASME.

J. E. Hughes, vice president of Henry J. Kaiser Co., has been appointed assistant general manager of the Kaiser Engineers division.

Most recently, as a vice president, Kaiser Engineers International, Inc., Hughes was responsible for all Latin American projects.

Appointed assistant to the vice president and assistant general manager, Kaiser Engineers in 1954, Hughes had earlier served as chief estimator and held various other engineering and managerial positions with the division. Hughes joined the Kaiser organization in 1941 following his graduation from the University of California as a civil engineer.

Dr. Ryden L. Richardson has been promoted to senior research chemist at Union Oil Co. of California's Research Center, Brea, Cal., according to an announcement by **Fred L. Hartley,** vice president of research.

Sir Kenneth B. Harper has retired from board of directors of The British Petroleum Co., Ltd., and has been replaced by Robert Paterson Smith.

B. W. Jesser has been named manager of Kellogg International Corp., London, a subsidiary of The M. W. Kellogg Co., New York. Jesser will relieve **F. E. Johnson, Jr.** who has been manager for the past four years and who has just been named an assistant engineering vice president of the parent company in New York.

Jesser

Jesser was a Contract Operations staff engineer in M. W. Kellogg's New York office, and was formerly manager of the company's Design Engineering department. He has been with the company since 1942. Prior to then he was an instructor in chemical engineering at Princeton University and with with DuPont.

Joe F. Alix and nine technical men have reported recently for work with the Research and Development department of

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Men in the Industry . . .

American Oil Co. in Texas City. The men were previously employed at the Amoco Chemical Corp.'s Brownsville, Texas, plant which was recently closed.

The group included: chemical engineers John J. Hagan, William F. Patton, Bobby D. Sager, Donald J. Shrecengost, and W. Gordon Thomson; and chemists Jerry B. Frost, Robert K. Klockmann, and Buell O'Connor.

Rowland C. Hansford has been named senior research associate at Union Oil Co. of California's Research Center.

Walter J. Porter, Jr. has been appointed assistant head of catalytic research and development at the Esso Research Laboratories, Baton Rouge, La.

He was advanced to his new post from petroleum pilot plant design work.

Porter received a B.S. degree in chemical engineering from Lehigh and an M.S. degree in chemical engineering from Louisiana State University.

The major part of Porter's career has been devoted to petroleum process development. He figured prominently in the development of the petroleum industry's first Fluid Molybdena Hydroforming pilot plant and served as liaison agent for the first Hydroforming unit installed by Standard Oil Company (New Jersey).

Savage

Ludwig

W. K. Savage has been named assistant superintendent, Manufacturing division light oil processing for The Texas Co.'s Port Arthur works. In other personnel changes **R. N. Ludwig** was named supervisor, light oil processing, succeeding Savage; **T. H. Tepper** replaces Ludwig as assistant supervisor light oil processing.

Tepper

Savage graduated in 1941 from the University of Texas with a B.S. degree in chemical engineering and was employed by the company in 1941.

Ludwig graduated with a B.S. degree in chemical engineering from Texas A & M College in 1937. He has been with the company since 1939, when he was employed as a chemical engineer.

Tepper, who came from Denver, graduated from Colorado School of Mines in 1949 with a B.S. degree in petroleum refining engineering.

John W. Conwell has been named senior research chemist and **John J. Guyer** has been named chemical engineer in the chemical engineering section of D-X Sunray Oil Co.'s Research and Technical Service division, Tulsa.

Conwell was with Continental Oil Co. before joining D-X Sunray. He holds B.S. and M.S. degrees in chemical engineering from Iowa State College in Ames and is completing work toward a Ph.D. degree at Oklahoma State University, Stillwater.

Guyer, formerly with the Institute of Gas Technology, Chicago, is a native of Newcastle, Penn. He holds a B.S. degree in chemical engineering from Purdue University, West Lafayette, Ind.

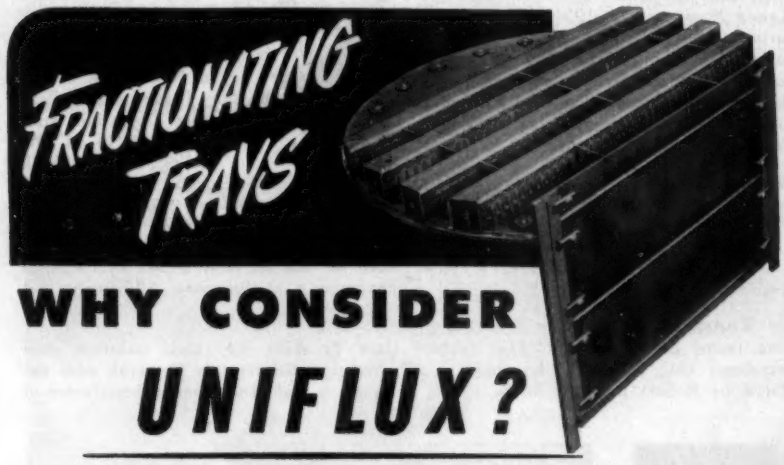
Turner C. Smith, chief structural engineer at the Torrance refinery of General Petroleum Corp., has retired after 32 years of service. He started with the company as a draftsman in 1926.

During 1952 and 1953 Smith worked with Socony Mobil Oil Co. on building design and construction in Caracas, Venezuela.

J. P. Markey, Wichita Falls, Texas, has been appointed assistant superintendent of Conoco's Lake Charles refinery. He formerly was superintendent at Wichita Falls.

M. H. Clark, Lake Charles, has been appointed superintendent at Wichita Falls, succeeding Markey. He formerly was assistant superintendent at Lake Charles.

A native of Louisiana, Markey was graduated in 1927 from Loyola Univer-



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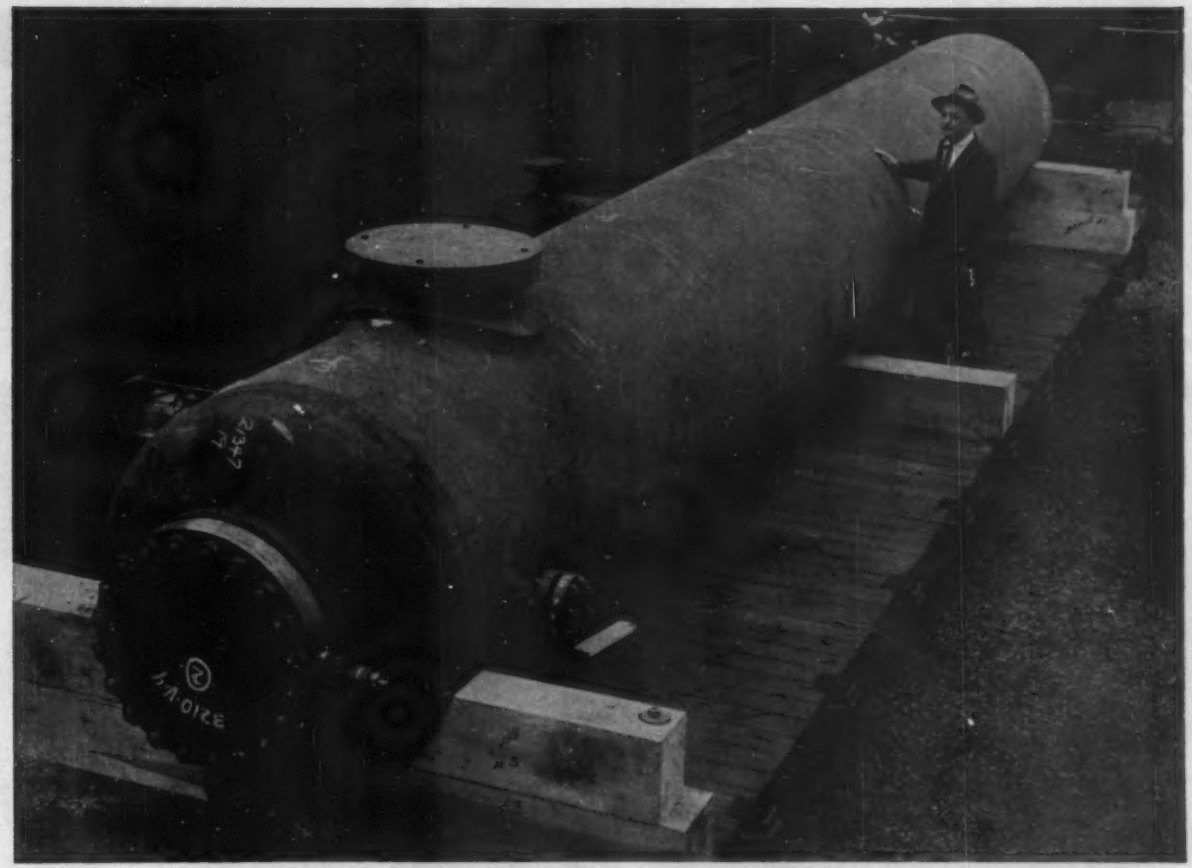

NEWPORT NEWS BUILT two 39'-7" horizontal gas scrubbers, such as this, for J. F. Pritchard & Co. They were made of ASTM-A212 Grade B fire box steel, with structural mesh steel interiors.

Gas scrubber made of 2⅞" steel

Newport News builds almost any type of pressure vessel and other heavy process equipment

Here is one of two horizontal gas scrubbers recently built for an operating pressure of 1800 psi at 300°F.

Newport News made both vessels from fire box steel, 2⅞ inches in thickness. We formed and automatically welded this steel into sections having a diameter of only 4 feet.

Rolling thick steel to this small diameter...no easy accomplishment, as you probably know . . . demonstrates the sort of jobs Newport News takes in stride.

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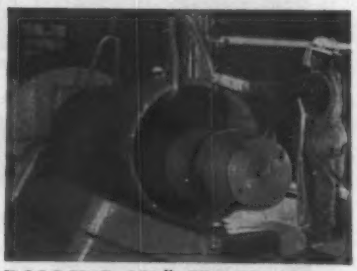

ROLLING 2⅞" STEEL for gas scrubbers. The steel, in a hot condition, was formed on the heavy bending equipment shown here. It will cold roll mild steel up to 3 inches thick, and will hot roll any grade of steel up to a thickness of 5 inches.

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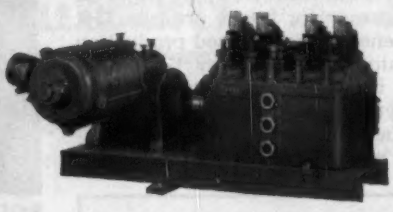

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Men in the Industry . . .

sity, New Orleans, and was a chemistry instructor at that school before joining Conoco in 1930 at Ponca City. He has served as resident chemist at the company's Denver, Colo., refinery and as assistant superintendent and superintendent at Wichita Falls.

Clark joined Conoco in 1930 at Ponca City and held several positions at the refinery there before transferring to Lake Charles in 1941. He served successively as special operator, stillman and shift foreman at Lake Charles before his promotion to assistant superintendent in 1948.

J. W. Saunders has been promoted to senior supervising engineer in Engineering division at Humble Oil & Refining Co.'s Baytown, Texas, refinery. He supervises a group that is engaged in design engineering work for construction and repairs. Saunders studied civil engineering at Arlington College and Texas University.

Patrick J. Keating, Jr., has been promoted to director of research at the Texaco Research Center, Beacon, N. Y. He was formerly assistant director.

Keating received his B.S. degree in chemical engineering from Rice Institute in 1931. He joined The Texas Company that year as a chemist at Port Neches Works.

Dan T. McDonald has been appointed executive vice president of Goliad Oil & Gas Co., and will be located in Calgary, Alberta, Canada. This company is currently constructing, and will operate, facilities for gathering and processing gas produced in the Pembina Field, Alberta. McDonald was formerly vice president of The Murmanill Corp., Dallas, and of several of its subsidiaries.

Redding

Fitzgerald

E. D. Redding and **R. M. Fitzgerald, Jr.,** have been named vice presidents and **J. W. Shackelford** has been named chief development engineer for Wyatt C. Hedrick Engineering Corp., Houston. Redding will head the chemical engineering division and Fitzgerald the project engineering division of the company.

Shackelford

Redding will be responsible for consulting services, economic development studies and process engineering. He had previously served as project engineer, chief

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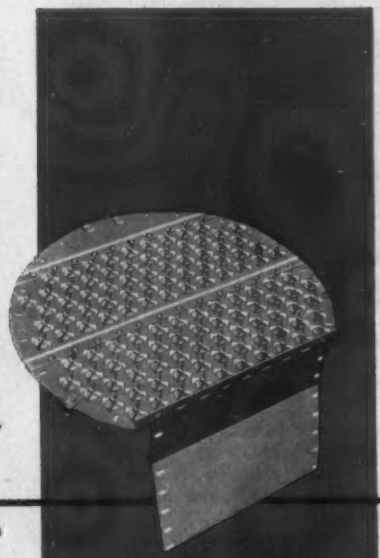

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Men in the Industry . . .

development engineer and executive assistant. He hold B.S. and M.S. degrees in chemical engineering from the University of Texas.

Fitzgerald, with four years experience with Hedrick has 16 years background in design and construction in the Gulf Coast chemical industry. A Rice graduate with a B.S. degree in mechanical engineering, he is registered in Texas as a professional engineer.

Shackelford was development engineering supervisor for the last two years. He has a B.S. degree in chemical engineering from Louisiana State University and an M.S. degree in chemical engineering from the University of Michigan.

Walter H. Rupp, a graduate of the University of Pittsburgh, has been appointed a senior staff engineer in the engineering coordination unit of Esso Research and Engineering Co.

Rupp began his Esso career in 1930 as a design engineer. He holds numerous patents and is the author of a number of publications in the field of general refining and air pollution.

In his new assignment, Mr. Rupp is responsible for the staff engineering activities for affiliates in Aruba, Cuba and South America.

Kenneth G. Holdom has been named manager of the eastern district with offices in New York City, of J. F. Pritchard and Co.

Holdom replaces **A. B. McClelland** who will become an executive of the Siboney Caribbean Oil Co., New York.

Holdom received his degree, in business and engineering administration, from Massachusetts Institute of Technology.

Dr. Heinz Heinemann has just joined The M. W. Kellogg Co.'s research department staff to assist in planning technical coordination and long range research. In this capacity, Dr. Heinemann will be associated with **Dr. Alex G. Oblad,** vice-president in charge of research and development.

Heinemann

Dr. Heinemann is president of the International Congress on Catalysis. He was formerly with Houdry Process Corp. in charge of a research section, with several oil refining organizations and has served on the faculty of Carnegie Institute of Technology.

Dr. Heinemann received a Ph.D. in Chemistry from the University of Basel, Switzerland, and also graduated from the University of Berlin and Technische Hochschule, Berlin.

Paul E. Nicholls, Jr. has joined Truman B. Wayne & Associates, Chemical and Engineering Consultants, Houston, as manager, Refining and Petrochemical Services.

Nicholls

He has been associated with The Gulf Publishing Co., Houston, since 1955 as maintenance and design editor of PETROLEUM REFINER, and market research director. His prior petroleum and process industry activity since 1947 includes engineering and coordinating positions with The M. W. Kellogg Co., C F Braun and Co. and General Electric Co.

Nicholls attended Texas A and M College where he majored in mechanical engineering.

B. Brewster Jennings, chairman of the board of Socony Mobil Oil Co., Inc., and chief executive officer of the company, has retired.

Albert L. Nickerson, president of Socony Mobil since July, 1955, will become chief executive officer of the company.

Fred W. Bartlett will succeed Jennings as chairman of the board of directors. Bartlett has been a director since 1953 and vice president for producing since May, 1957.

Jennings, who has been chief executive officer of Socony Mobil for more than 13 of his 37 years with the company, became president in 1944 and chairman of the board in 1955.

Following his retirement, Jennings will devote a considerable portion of his time

Weldynamics

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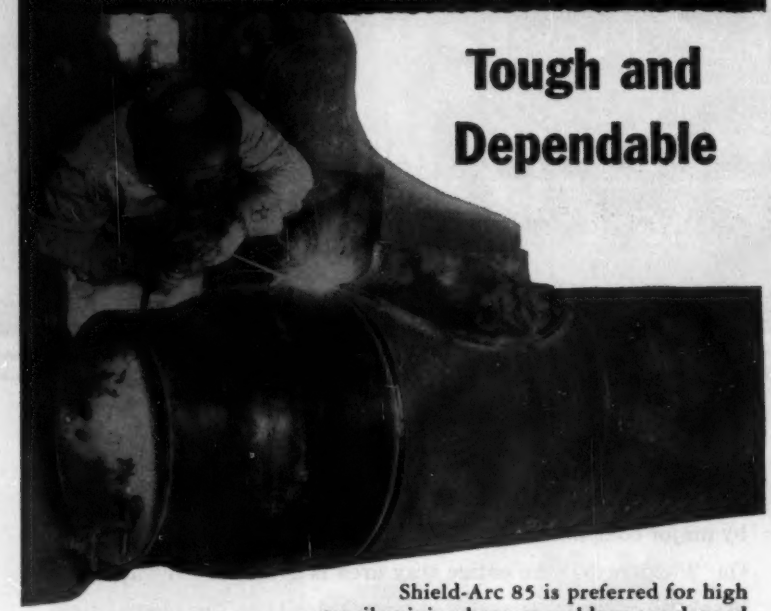

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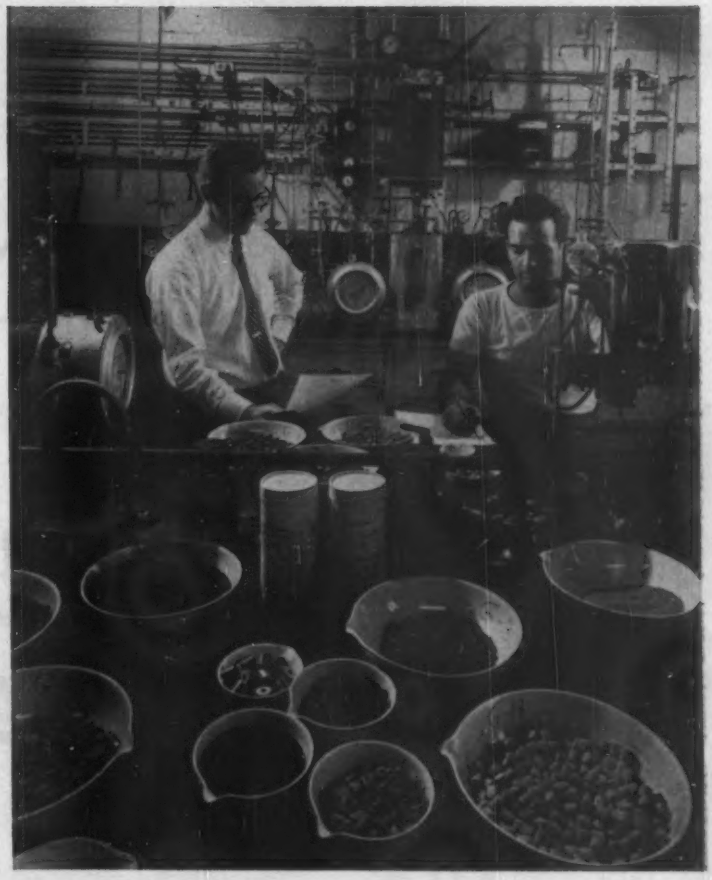

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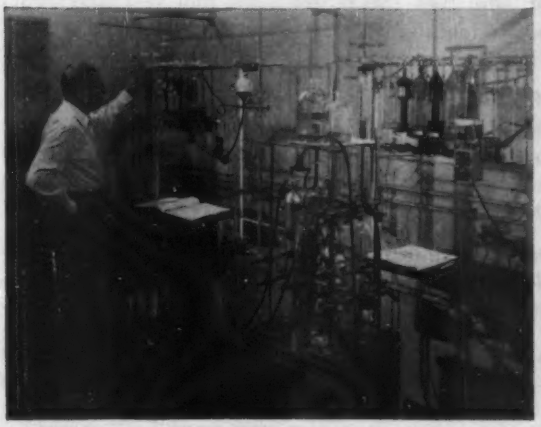
Catalyst Research is an important part of Girdler's full-scope catalyst service to assure you optimum performance . . . lowest operating cost. Girdler Research teams up with your technicians to custom-design *the* catalyst to meet your requirements.

Write for booklet on Girdler's complete catalyst facilities . . . its Application Service, Research Service, Analytical Service, Manufacturing.



Girdler's highly skilled development staff works on *your* process problem to give you optimum catalyst performance.

Girdler manufactures your catalyst in modern facilities with highest standards of quality control.

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AMOCO CHEMICALS—A NEW RESOURCE

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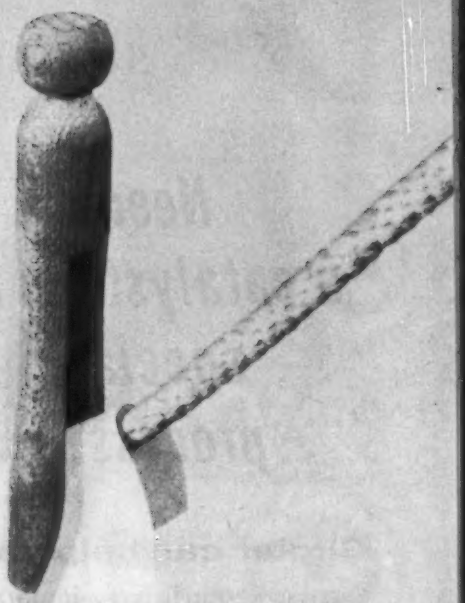

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Familiar Products: Sulfurized hydrocarbon and zinc dithiophosphate type inhibitors. Organic barium and potassium salt detergents. Detergent-inhibitor blends with exceptional properties to produce heavy-duty motor oils to meet all performance criteria. Multifunction fuel oil additive.

New Products: Amoco polyisobutylene VI improver for multigraded motor oils. A metal deactivator and three antioxidants—used primarily in gasolines.

Amoco Additives have been thoroughly laboratory and field tested by men experienced in this work. Sales engineers qualified to discuss additive problems will call on you upon request. Your inquiry will receive immediate attention.

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to other interests, primarily those connected with education and philanthropy.

At the age of 46, Nickerson becomes the top officer of Socony Mobil which he joined shortly after graduation from Harvard in 1933.

In 1945, Nickerson went to London with Vacuum Oil Co., Ltd., the British affiliate of Socony Mobil. On January 1, 1946, he was named chairman of the board of Vacuum Oil, Ltd.

Later in 1946 he returned to the United States to become a member of the Socony Mobil board of directors and executive in charge of domestic marketing. He held this post for five years after which he took charge of the company's foreign marketing and refining as a vice president.

Bartlett, now 60 years old, graduated from the University of Michigan in 1921. He joined Socony Mobil in 1939 after 17 years of oil experience in the United States and Mexico.

J. Gregory Harrison, assistant engineer at Texaco's Eagle Point refinery at Westville, N. J., was recently promoted to engineer in the Plant Engineering department. He joined Texaco in June of 1954 at its Eagle Point refinery following his graduation from Clarkson College of Technology, Potsdam, N. Y., with a B.S. degree in civil engineering.

C. R. Frohlin has been named assistant manager of Texaco's Advertising division. Frohlin, formerly New York division sales manager, will succeed **A. R. Dunphy**, who will retire next month.

Neil H. Illian has been promoted to chief project manager for The Refinery Engineering Co., Tulsa. He succeeds **Harold F. Koons,** who recently was named sales development engineer to head a newly-created group in the Treco sales department.

Illian

Illian moved to Treco in November of 1955 from Blaw-Knox Co.'s chemical plants division in Tulsa. He was project engineer there for four years, later becoming assistant chief engineer.

Previously, Illian had been an engineer in the design section of Phillips Petroleum Co., Bartlesville and in the engineering and construction department for Jones & Laughlin, Tulsa.

He graduated from Kansas State College in 1947 with a B.S. degree in mechanical engineering.

Dr. T. H. Rogers, director of research for the Standard Oil Company (Indiana), has retired. He joined the company's research staff at Whiting, Ind., in 1922.

After obtaining his Ph.D. degree in physical chemistry at Johns Hopkins university in 1917, Dr. Rogers served in the Army Chemical Warfare Service. He was one of the group that discovered Hopcalite, a catalyst used in gas masks to deactivate poison gas.

At Standard, his early researches dealt principally with anti-oxidants, white oils, and the finishing of distillate fuels and motor oils. His later activities cover the entire field of petroleum chemistry.

J. R. Cutler has been named superintendent of the Texas Co.'s West Tulsa refinery.

Before his appointment, Cutler was assistant superintendent of light oil processing of the Manufacturing department at Texaco's Port Arthur, Texas, refinery. He succeeds **J. J. Rasor.**

Cutler

Cutler received a B.S. degree in chemical engineering from The University of Texas in 1932, and joined Texaco the same year.

Men in the Industry . . .

Dr. George Matsuyama has been named research associate at Union Oil Co. of California's research center.

– Deaths –

Andrew K. Brumbaugh, 47, assistant manager of the refinery engineering division of Socony Mobil Oil Co., Inc., and an employee of that company for the past 19 years, died last month.

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the Dean Hill sulphur pump

low cost operation

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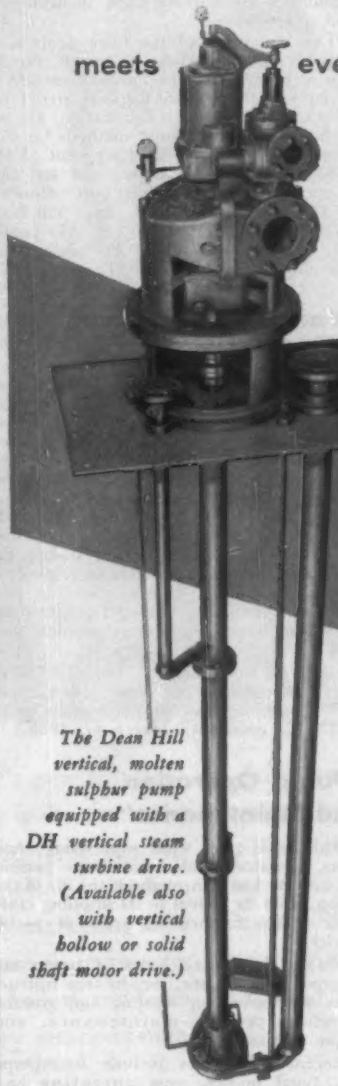
reliability



The Dean Hill vertical, molten sulphur pump equipped with a DH vertical steam turbine drive. (Available also with vertical hollow or solid shaft motor drive.)

Like all Dean Hill products, this sulphur pump incorporates all of the features to give you years of trouble-free operation. Complete steam-jacketed line shaft and discharge column assures free flow at all times. Actual liquid sulphur lubricates bearings and shaft damping bushings. The Dean Hill sulphur pump is a compact, self-contained, rigid, smooth-running mechanism capable of superior service at all times. For complete information write today, without obligation.

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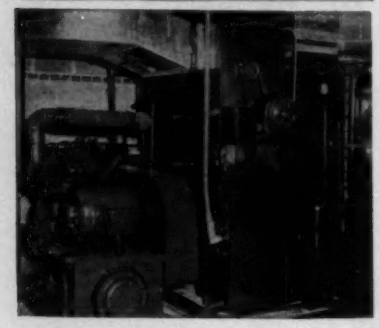

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Reviewing New Books . . .

"Plant Design and Economics for Chemical Engineers"

Written by Max S. Peters, this book emphasizes the essential combination of economic analyses with plant design considerations.

The first part deals with applied economics. The various costs involved in industrial processes, capital investments and investment returns, cost estimation, cost accounting, optimum economic design methods, and other subjects dealing with economics are covered both qualitatively and quantitatively.

The remainder of the book deals with methods and important factors in the design of plants and equipment. Generalized subjects, such as waste disposal, structural design, and equipment fabrication, are included along with design methods for different types of process equipment. Basic cost data and cost correlations are also presented for use in making cost estimates.

(McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y., 511 pages, $11.00. For sale by Gulf Publishing Co., P.O. Box 2608, Houston 1, Texas, U.S.A.)

"Van Nostrands Scientific Encyclopedia"

This book contains over 1400 photographs and diagrams. Covering areas that extend over the physical sciences, engineering and medicine, including many related subjects, this book has been prepared by leading scientists. The main subjects are chemistry, nuclear science and engineering, guided missiles, metallurgy, chemical engineering, physics, electrical engineering, mechanical engineering, electronics, astronomy, navigation, meteorology, photography, aeronautics, civil engineering, statistics, mathematics, geology, mineralogy, radio and television, botany, zoology, and medicine.

(D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, New Jersey, over 1800 pages. Special prepublication price of $26.85, good until March 17, 1958.)

"Pump Operation and Maintenance"

This book gives what supervising engineers, operators, and maintenance personnel need to know throughout the life of the pump, from its arrival in its shipping crate until it has finished its years of useful service.

Major classes and types of pump are covered, with specific, step-by-step instructions for installing, starting up, routine operation, periodic maintenance, and major overhaul.

Recent advances include barrel-type centrifugal pumps, new operating and maintenance forms and scheduling methods, late developments in pump shaft metallizing, new process-type centrifugal pumps, new chemical-type centrifugal pumps, and a large number of new metering and proportioning pumps.

(McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y., 275 pages, $9.00.)

"Electrostatics in the Petroleum Industry"

The static electricity which gives rise to many disasters is produced while an oil product is being pumped into a tank. The explosion occurs when the contents are measured with a steel dip tape, which takes an electric charge from the liquid. A spark then jumps from the tape and ignites the vapor.

Until recently, no practical methods were known for preventing high voltages from being generated by flowing petroleum products. This difficulty has now been overcome. The means that can be taken to put an end to the hazard of electrostatic explosions are fully described in this book and so are the principles and research underlying these safety recommendations.

(D. Van Nostrand Co., Inc., 257 Fourth Ave., New York 10, N. Y., 191 pages, $8.00. For sale by Gulf Publishing Co., P.O. Box 2608, Houston 1, Texas, U.S.A.)

"Appraisal and Evaluation Manual"

This manual is offered by the American Society of Appraisers and valuation engineers with offices in Washington, D. C.

The studies in the Manual comprise a wide range of topics on every phase of valuation and appraisal in all branches of real estate, architecture, building construction, public works, engineering, insurance, accounting, law, taxes, assessments, banking and finance, public utilities, industry, commerce, fine arts and antiques, plus every facet of government.

This volume has a greatly expanded and up-to-date Bibliography of reference books useful to appraisers and valuation engineers. Further additions have also been made to the section on "Words and Phrases" related to the work of the appraiser as expressed in formal court opinions.

(American Society of Appraisers, Manual Division, 369 Lexington Ave., Suite 1105, New York 19, N. Y., 500 pages, $15.00.)

"Industrial Chemicals" Second Edition

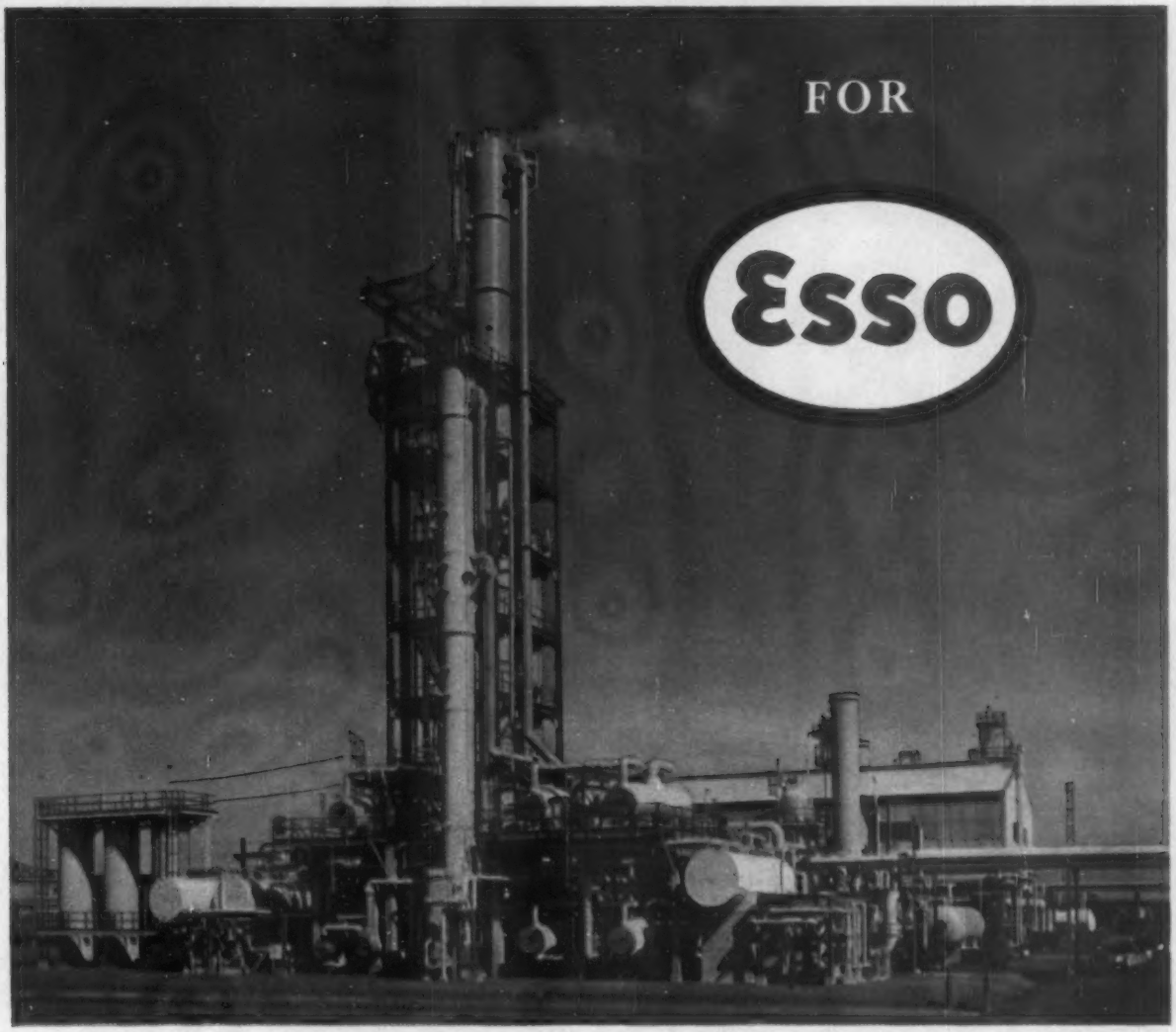
Written by W. L. Faith, Donald B. Keyes and Ronald L. Clark, this new edition treats each chemical individually in a separate chapter, supplying the following information on each:

- how it is made (with important process details)
- how it is used
- how much has been produced each year for the past 20 years
- the price range for the past 20 years
- the important chemical and physical properties of the material
- the usual grades
- how it is packaged and shipped
- who makes it and where
- important economic trends

(John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 844 pages, $16.00. For sale by Gulf Publishing Co., P.O. Box 2608, Houston 1, Texas, U.S.A.)

For more data on advertised products, use Readers' Service Cards, last page.

EAST COAST ETHYLENE



ESSO STANDARD OIL COMPANY's new Ethylene Plant at Bayway, New Jersey is the first to be located on the East Coast. The ethylene product is distributed through Esso's pipeline system to petrochemical plants in this strategic marketing area.

The plant produces its own steam from transfer line heat exchangers and waste heat boilers, and pipes surplus steam to the Esso refinery steam system.

Refinery gas forms the feedstock for this large capacity, high purity ethylene plant.

The plant is typical of the design, construction and engineering services Stone & Webster Engineering Corporation provides the process industries for every type of installation, both large and small, throughout the free world.

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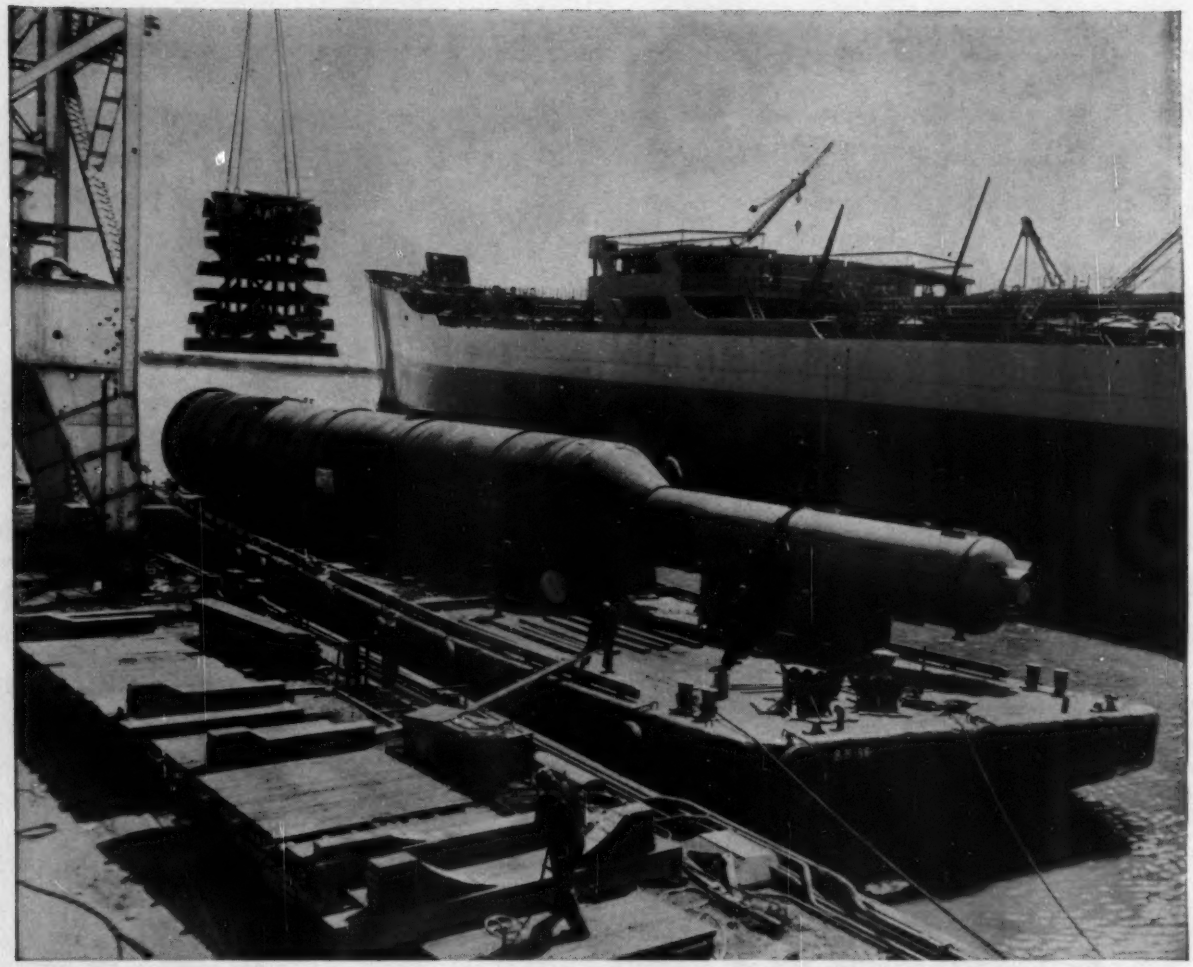

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What Suppliers Are Doing . . .

Jones

William R. Jones has recently been named product manager of Soft Packing for The Garlock Packing Co., Palmyra, N. Y., according to an announcement by **Richard C. McGonigal**, manager of product planning. In his new capacity Jones will assume responsibility for the marketing of Garlock's entire soft packing line. Former office manager and secretary of The Garlock Packing Co. of Canada, Ltd., Jones has been with Garlock since 1935. He attended Hamilton College.

Bradbury

Walden E. Bradbury has been named manager of Consolidated Electrodynamics Corp.'s district sales office in Washington, D. C. Bradbury succeeds **Albert W. Brandmaier**, recently appointed manager of CEC's European sales office which moved from Zurich, Switzerland, to Frankfurt, Germany.

For the past two years, Bradbury has been a field engineer in the Washington office. He joined the company in September, 1954, as a service engineer in the same office. Previously, he was an instrumentation engineer with E. I. du Pont de Nemours & Co., and Fairchild Camera and Instrument Corp.

A graduate of the University of Miami with a B.S. degree in engineering, Bradbury is a member of the Instrument Society of America and the Institute of Radio Engineers.

Gordon

J. Roy Gordon, Canadian and American industrialist and metallurgist, was elected to the board of directors of The Babcock & Wilcox Company at its meeting here recently.

Gordon is executive vice president, a director and member of the executive committee of the International Nickel Co. of Canada, Ltd., and is executive vice president and director of International Nickel Co., Inc.

West

William C. West, Jr., 38, has been elected president of West Instrument Corp., succeeding his brother Richard K. who was lost in a recent airplane accident.

Bill West was one of the founders of the Chicago manufacturing firm, and had been vice president and secretary until the current election. He attended Illinois Institute of Technology, is a member of the Instrument Society of America and well known in his field.

William A. Kelly, attorney and director, was elected secretary.

Wroe

Robert L. Wroe, formerly in charge of accessories promotion with the Foxboro Service and Repair division, has been appointed an instructor in the Training Center of The Foxboro Co., Foxboro, Mass. He is currently furnishing bench instruction and lecturing on mechanical instruments.

Wroe has had experience in a number of divisions of the company during his past 15 years of service. He is a graduate of the University of Massachusetts where he received his B.S. degree and prior to that attended Northeastern University.

Arnold

Jack Arnold, Jr., has been appointed supervisor of the Boston office, 135 Clarendon Street, of The Enjay Co. He has been filling this position on a rotational basis since April, 1957.

Arnold graduated from Rice Institute with a B.S. degree in chemical engineering. Before joining Enjay, he served as an industrial salesman with an affiliated company. In 1955, he joined Enjay and worked in polymer sales in New England.

As supervisor of the Boston office, he will report directly to **J. P. Haworth**, eastern division manager.

Radford

Admiral Arthur W. Radford, former chairman of the Joint Chiefs of Staff, has been elected a member of the board of directors of Worthington Corp.

Admiral Radford recently retired from the Navy after 45 years of distinguished service. His combat commands included a carrier task force in the Pacific during World War II, and he was Commander in Chief of the Pacific Fleet in the early stages of the Korean War. He made important contributions to the development of the Aeronautic organization of the Navy, and to Naval post-war planning. He was first appointed chairman of the Joint Chiefs of Staff in 1953, and re-appointed for a second term in 1955.

Zimmerman

S. R. Zimmerman, Jr., has been named general manager of its Raybestos-Manhattan, Inc.'s, U. S. Asbestos—Grey Rock division, Manheim, Penn.

Zimmerman has been with the division for the past 25 years, recently as assistant general manager. He is also a vice president and director of Raybestos-Manhattan.

O. H. Cilley, whom Zimmerman succeeds, continues as a vice president and director of the corporation, and also in an advisory and consulting capacity.

Hilborn

Ralph D. Hilborn has been appointed to the newly-created position of division controller of Jones & Laughlin Supply division.

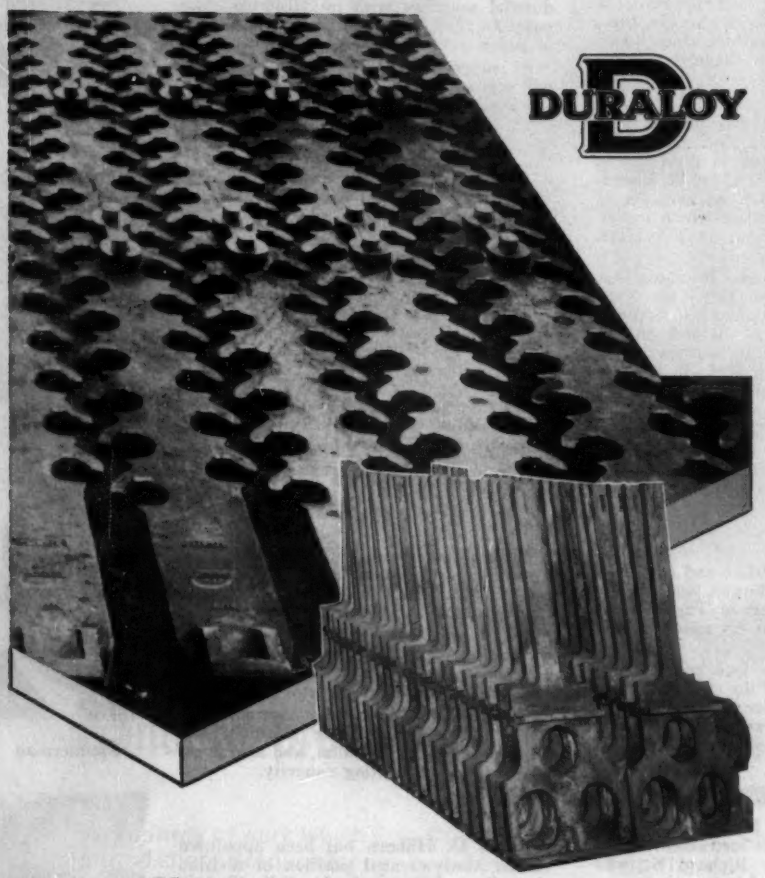
Hilborn, who was chief accountant for the Supply division, has been associated with J&L since April, 1938, when he was employed as an assistant auditor in the Pittsburgh office of Jones & Laughlin Steel Corp. He was promoted to auditor in the Supply division, Tulsa, in January, 1941, and was named chief accountant for the division on February 1, 1953.

A native of Kane, Penn., Hilborn attended schools there. He also completed accounting courses at LaSalle University in 1928.

Williams

Dr. Van Zandt Williams has been named executive vice president of The Perkin-Elmer Corp. Dr. Williams has been with Perkin-Elmer since 1948, when he joined the company as director of instrument development and sales. In 1951 he was elected a vice president and director of the corporation and director of sales and research. He became general manager of the

CORROSION RESISTANT
HEAT RESISTANT
Tube Supports



You can't buy Better Tube Supports . . . DURALOY Tube Supports are alloyed to meet individual corrosion and heat requirements. They are alloyed by experienced metallurgists and melted and cast by experienced high-alloy foundrymen, both groups with experience going back some thirty years. Castings are carefully tested in our own laboratories which are completely equipped for metallurgical, chemical and physical testing.

Many refineries have been DURALOY customers for years. Many refineries insist upon DURALOY castings. Whether it's straight production or engineering plus production, we are equipped to do the job. For more information, send for Bulletin No. 3150-G.

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Suppliers . . .

newly formed Instrument division in 1956 and held this position until his recent appointment.

Before joining Perkin-Elmer, Dr. Williams was with American Cyanamid Co. at its Stamford, Conn., Research Laboratories. There he specialized in infrared spectroscopy, an analytical technique. From 1943 to 1948 he was assistant director of the Physics division, and during the war period he worked on certain aspects of the Manhattan Project. Dr. Williams is a graduate of Brown University and received his Ph.D. degree in physics from Princeton University in 1941.

MacDonald

Fives

CARRIER CORP. has announced three promotions in the Machinery and Systems division. **William H. McDonald** has been named assistant manager of the machinery department, a new post. Succeeding him as product specialist of industrial air and gas compressors at the company's Syracuse, New York, headquarters will be **Frank M. Fives**, who was senior sales engineer for this equipment in the New York regional office.

Shields

Clark T. Shields will move from the Chicago office to take over sales of these products throughout the northeast.

Macdonald will assist **Elbridge Gammill**, machinery department manager, who is in charge of engineering and production of absorption, centrifugal and reciprocating refrigeration units.

Macdonald has spent his entire business career with Carrier, excluding three years in the United States Army, since graduating from Lehigh University 22 years ago. He has specialized in sales and engineering of the company's heavy machinery.

Fives has been with Carrier for 12 years. Except for four years service with the U. S. Navy during World War II, he has been associated with the compression field since graduating from Carnegie Tech in 1939.

Shields started as a student engineer with Carrier in 1936 after receiving a B.S. degree from Union College. He has recently been responsible for centrifugal compressor sales and engineering in the Midwest region.

JONES & LAUGHLIN SUPPLY DIVISION, Tulsa, has appointed **John L. Leimbrook** salesman at the Farmington, N. M. store. Leimbrook, a graduate of A&M College of Texas, began his career with J&L

Carbon Monoxide Boiler at Sun Oil Company's Toledo refinery.

3 B&W Carbon Monoxide Boilers Save Fuel For Sun Oil

Sun Oil Company has three B&W Carbon Monoxide Boilers in its refineries at Toledo, Ohio, and Marcus Hook, Pa. All are used with Houdriflow cracking units. The first boiler went on stream at Toledo four years ago. The second, at Toledo, and its twin at Marcus Hook, are of the oxycatalyst type.

The three B&W "CO" Boilers are effecting substantial fuel economies at both refineries.

Cracking units at Sun Oil, like others using B&W "CO" Boilers, are completly independent of outside steam and energy sources at all times. Whether or not the cracking unit is operating, steam is always available.

Extended, sustained service has proved the reliability, efficiency, and economy of B&W "CO" Boilers in refineries throughout the nation. They are flexible in design and arrangement to meet varying refinery conditions. B&W engineers can show you how a "CO" Boiler can serve your refinery, regardless of size, steam pressure and temperature requirements. Write for Bulletin G-87. The Babcock & Wilcox Company, Boiler Division, 161 East 42nd Street, New York 17, N. Y.

G-824 CO

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BOILER DIVISION

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seals MORE joints

per DOLLAR

Here's proof that Rectorseal gives you much more for your money. You not only get better, more dependable leakproof seals —but more of them from every can or tube of Rectorseal.

Here are the results of tests to determine the number of pipe joint threads that can be coated with Rectorseal and other compounds. Rectorseal coated ⅓ MORE joints than the nearest competitive brand; and 2½ times more than another brand.

Brand	Number of 2" pipe joints coated, per pint.
RECTORSEAL	448
Brand "A"	192
Brand "B"	224
Brand "C"	336

Start using Rectorseal now—be sure of leakproof joints, and get more seals per dollar for economy.

Rectorseal No. 2
— Dries fast
— Sets soft.

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Both can be used for the same services. Specify your preference when writing for sample.

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THE POSITIVE LEAK PREVENTER

Suppliers . . .

Supply on January 1, 1957, as a salesman at Alice, Texas. Previously he had been a sales trainee in the Pittsburgh office of Jones & Laughlin Steel Corp.

Paul C. Smith, formerly salesman at Pawhuska, Okla., has been transferred to Woodward, Okla. Smith was first employed as a storeman at the Bartlesville store in 1953. He was appointed salesman at Pawhuska in December, 1955.

THE CHEMICAL AND INDUSTRIAL CORP. at the Chemical Show held recently in New York, displayed a one-fourth inch scale model of Ohio-Standard's nitric acid and ammonium nitrate solutions plant. This model was also of great value to the con-

DURAMETALLIC PACKINGS MEAN LONGER SERVICE, LESS FRICTION ON SHAFTS AND FEWER SHUT-DOWNS

WRITE TODAY for File No. PR-DM covering a variety of types and styles of Duralmetallic and Dura Plastic Packings.

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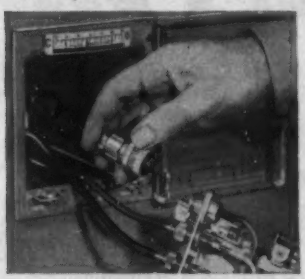
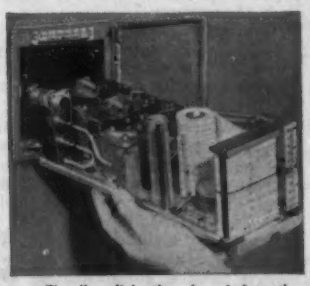
KALAMAZOO MICHIGAN

Shipment and installation of cases allows immediate completion of piping, checking of air lines and valve operation...



...Then you can install the recorder or indicator chassis, simply by reaching into case and attaching three finger-tight, self-sealing connections...



...Finally, slide the chassis into the case, and your process is on automatic control.

Immediate Delivery of TEL-O-SET* cases

install them in your panel now—insert TEL-O-SET instruments at startup

Let Honeywell *Tel-O-Set* recorders and indicators help you to start panel construction immediately. Here's how. Order the cases for the recorder and indicator now. Cases, available from stock, can be shipped separately to the panel manufacturer or to your plant site. Make complete piping connections, check air lines and valve operation . . . then install the chassis and controller later, at startup.

The indicator and recorder chassis don't have to be unpacked until you're ready for startup. That way, the instruments are fully protected against damage, and safeguarded from dust and dirt.

Call your nearby Honeywell sales engineer for a discussion of this new shipping plan, and for more information about *Tel-O-Set* instruments. Or write for your copy of the new *Tel-O-Set* Catalog, No. C1001-1.

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How to determine if mechanical seals will SAVE YOU MONEY

Mechanical seals can play a vital, *often unsuspected* role in the economics of your plant operation.

FOR EXAMPLE—

PRODUCT LOSS	Eliminating gland leakage prevents loss of valuable products . . . which could be substantial over a period of time. **How much would you save?**
TIME	Maintenance personnel time is minimized . . . and labor costs required to clean areas around leaking glands are eliminated. **How much would you save?**
INVESTMENT	You protect your overall investment by doing away with the prime trouble spots in handling dangerous, noxious, corrosive products. **How much would you save?**

FIND OUT HOW MUCH YOU CAN SAVE!

Send for your free do-it-yourself Cost Analysis Bulletins. See for yourself exactly how you can reduce Product Loss—Save Time—Protect Investment.

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Please send me Cost Analysis Bulletins.

Name..... Title.....

Company.....

Street.....

City..... State.....

Suppliers . . .

struction team during the actual erection of the plant.

Pictured are C&I men (left to right) Angus M. Taylor, Jr., Robert McConnell, Tom Long, and Bernie Burke.

UNITED STATES STEEL CORP. has transferred **Donald P. Ruhl,** Oil Well Supply division field representative at Farmington, N. M., to Blanding, Utah, it was announced by **R. L. Armstrong,** Rocky Mountain area manager.

Ruhl was employed in 1955 at Fort Morgan, Colo., and worked for "Oilwell" at this location and at Casper and Farmington prior to his present appointment.

TRACERLAB, INC., has announced that **Dr. George Manov,** former technical assistant to Atomic Energy Commissioner Willard Libby, is joining the firm as technical director of Tracerlab's Reactor Monitoring Center in Richmond, Calif. Dr. Manov has been a pioneer in the development of isotope applications and is well known for his work in the nuclear field. A graduate of the University of California with a B.S. degree in Chemistry, he subsequently did graduate work in physics. He spent twelve years in the U. S. Bureau of Standards working on radioactivity and then went to work for the AEC in 1948 at Oak Ridge, Tenn. In 1954 he was appointed assistant director of Office of Industrial Development of the AEC.

Manov

REPUBLIC FLOW METERS CO., a subsidiary of Rockwell Manufacturing Co., has named **Rowland B. Drescher,** assistant sales manager. He was formerly Pittsburgh district manager for Republic Flow Meters. In addition to his sales duties, he will supervise the engineering of contracts placed with Republic.

Drescher joined Republic Flow Meters in 1937 as a service engineer in the Chicago headquarters office. He went to Pittsburgh to represent the company in 1945.

He graduated from Rensselaer Polytechnic Institute in 1932 with a B.S. degree in mechanical engineering.

KEASBEY & MATTISON CO., has named **Clifford O. Hodges** plant accountant of the company's Meredith asbestos textile plant it was announced by **George Barge,** K & M treasurer.

Prior to joining K & M in November, he was associated with the Laconia Needle Co. where he was employed in an administrative capacity.

UNITED STATES STEEL CORP. has appointed **Traver E. Hartill** assistant district director—public relations in the Southeast district, it was announced by **Clinton R. Milstead,** district director. Hartill's office will be in Fairfield, Ala.

A native of Cambridge, Ohio, Hartill attended Indiana University where he studied business administration. He joined U. S. Steel in 1936 as an accounting clerk at the South Chicago Works. He was transferred later that year to the Gary, Ind.,

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proven
construction

Prevents Freezing of

OCECO V-130 Conservation Regulators

Positive flexing action of pliable cold and heat resistant membrane, held under tension, peels off icy formations without exceeding set pressures.

NEVER A REPORTED CASE OF VALVE FREEZE-UP

Oceco V-130 Conservation Regulators bring never before secured economy and dependability to the conservation of volatile products stored in cone, round, flat, lifter or expansion roof tanks. Our exclusive pressure balanced construction prevents freeze-ups and protects the tank from excessive pressure and vacuum even under the most severe weather conditions. These regulators prevent vapors from escaping at less than operating setting and **provide greater flow capacity, size for size, and pressure for pressure,** especially at low pressures, **than ever before available.** Write for Bulletin No. 522. It gives full details!

PRESSURE BALANCED CONSTRUCTION. Tank pressures exerted on both sides of the pliable heat and cold resistant membrane keep membrane always under tension; —assuring tight seating fully up to operating setting—and positive flexing action that peels away icy formations preventing freeze-ups.

EXCLUSIVE OCECO FEATURE SAVES YOUR VAPOR DOLLARS!

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M&L CARBON STEEL REBOILER—made to A.S.M.E. code for a well known Texas petrochemical company. (Design pressure 150 P.S.I., design temp. 300°F, O.D. [shell] 32½", 11' 3" long.)

Today's rapid strides in the technology of processing plant operation make it essential for a manufacturer of equipment to be "staffed up" with people who have had extensive training and experience. More than half our staff have spent a major part of their working life in this one field and have played a major role in the design and fabrication of many types of processing equipment. They know the limitations and workability of all metals and how to get maximum service from each. This accumulated knowledge of base materials and our extensive experience in design and fabrication means practical, trouble-free equipment at the lowest possible cost.

It is impossible, in a field requiring such wide diversification, to illustrate, or even list, all the products we have been called upon to supply. The reboiler above is simply one among thousands.

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Suppliers . . .

Sheet and Tin Mill accounting department and became assistant chief storekeeper in 1940. He was promoted to field supervisor—industrial relations in 1947.

In 1952 he was appointed assistant public relations representative in U. S. Steel's Gary, Ind., public relations office. In 1954 he was named public relations representative in Chicago and in 1956, was promoted to assistant to district director of public relations in Chicago, the position he held until his present appointment.

TRACERLAB, INC., has just added **Major Gen. Russell L. Maxwell** to its Washington stac as a consultant to provide liaison between Tracerlab and various government agencies interested in nuclear techniques in research and production.

President **S. S. Auchincloss,** in commenting on Tracerlab's increased activity in this field, said that while in the past Tracerlab like many other companies has been reluctant to take on government business because of its questionable profitability, it is now felt that with proper direction a program of government sales would be profitable to both the firm and its clients in government.

NORTON CO.'S Research and Development department has been reorganized to correspond with the company's divisional reorganization announced a year ago.

Dr. Lowell H. Milligan, formerly assistant director of research and development has been appointed associate director of research and development. In this newly-created staff position, he will be responsible for liaison with patent attorneys on laboratory patent matters, and progress of outside research projects. He will also be available for consultation on ceramic projects within the department.

Dr. Neil N. Ault has been appointed assistant director of research and development in charge of the Refractory section.

Dr. Ault joined Norton Co. in 1950, the same year he received his Ph.D. degree in ceramic engineering at Ohio State University.

Loring Coes, Jr., continues as assistant director of research and development but will now be in charge of the Exploratory Research section. Coes received both his B.S. and M.S. degrees from Worcester Polytechnic Institute. He has been with Norton since 1938.

Drs. Herbert F. G. Ueltz, Guy Ervin, Jr., and **Leo P. Tarasov** have been appointed research associates. Dr. Ueltz received his degrees in ceramics at Rutgers University. He first joined Norton in 1949 along with Dr. Ervin who received his Ph.D. degree that year from Pennsylvania State University.

Dr. Tarasov, a graduate of Case Institute of Technology and Massachusetts Institute of Technology, has been a member of the department since 1941.

Dr. Newman W. Thibault continues as assistant director of research and development, a post he has held since 1953, but will now be in charge of the Abrasive section. **Yngve H. Nordstrom** has been appointed chief of the organic bond unit of this section and **John K. Sjogren** is now chief of the vitrified bond unit.

C. Herbert Quick will continue as assistant to the director of research and development and will now be in charge of the Service Section.

The Service Section has likewise been divided into units. **Raymond M. Rebert**

The First HEXANE ISOMERIZATION

In a program to increase octanes of field distillate-derived motor fuels, Atlas Processing Company at Shreveport, Louisiana, has selected HUDSON to construct a normal hexane isomerization unit – the first contracted to be built. Low octane hexane will be fractionated from the total refinery feed stocks, and catalytically converted to high octane fractions to give substantial increase in octanes of finished gasolines.

Through 25 years of ever-changing process techniques HUDSON has served the refining and natural gas industries – completing major projects throughout the free world, and building the HUDSON reputation for experience, integrity and ability.

DESIGNERS AND CONSTRUCTORS OF PROCESS PLANTS FOR THE OIL, GAS, CHEMICAL, AND MINING INDUSTRIES

HUDSON
ENGINEERING CORPORATION

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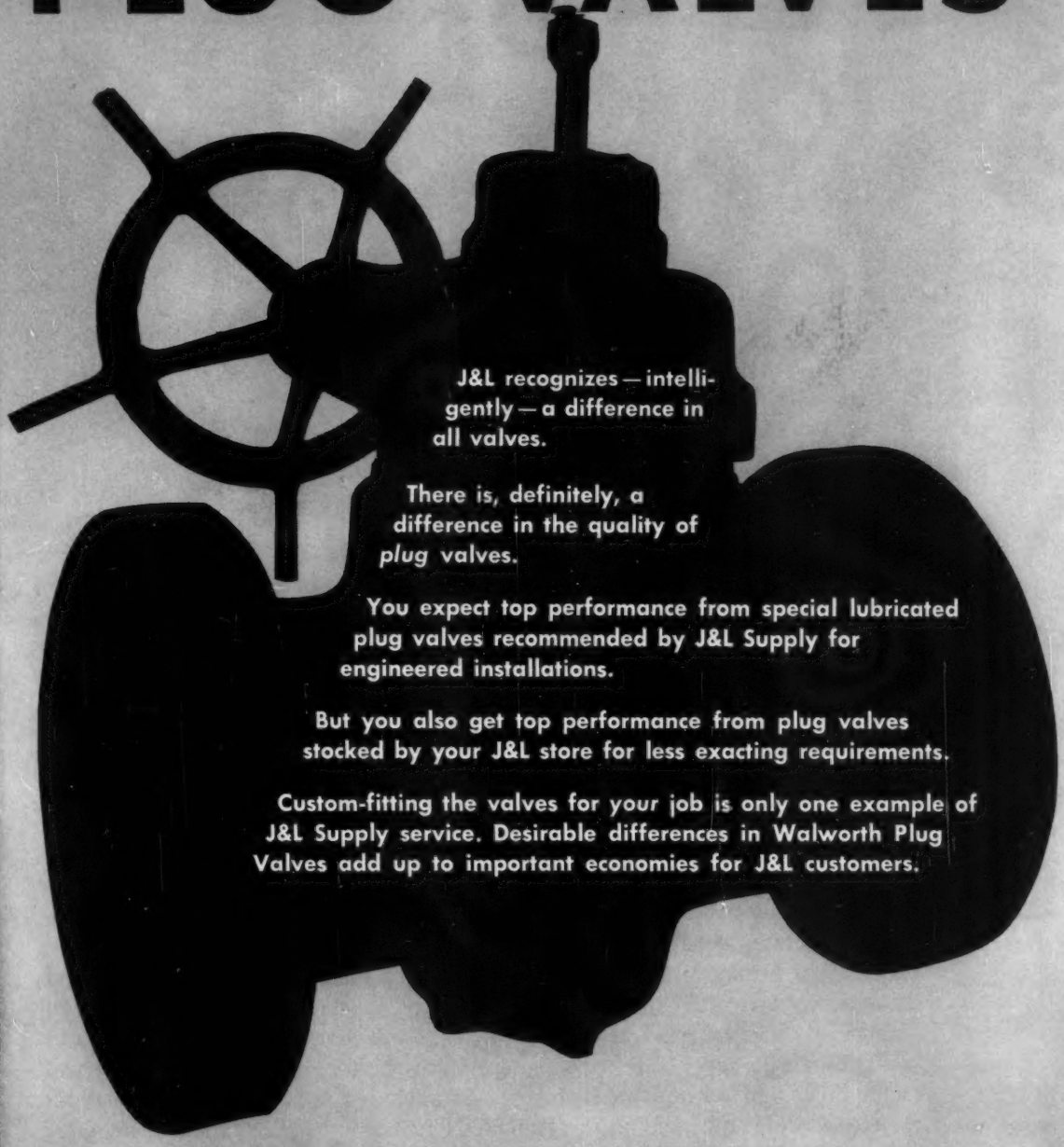
J & L recognizes a difference in

PLUG VALVES



J&L recognizes — intelligently — a difference in all valves.

There is, definitely, a difference in the quality of *plug* valves.

You expect top performance from special lubricated plug valves recommended by J&L Supply for engineered installations.

But you also get top performance from plug valves stocked by your J&L store for less exacting requirements.

Custom-fitting the valves for *your* job is only one example of J&L Supply service. Desirable differences in Walworth Plug Valves add up to important economies for J&L customers.

Jones & Laughlin

SUPPLY DIVISION – Tulsa

J&L – A GREAT NAME IN SUPPLIES

26

Suppliers . . .

continues as chief chemist in charge of the Analytical unit. **Richard E. Englund** is appointed chief in charge of the Grinding unit, **Charles W. H. Barnett** is appointed chief in charge of the Microscopic unit and **L. Peter Jensen** has been named chief machinist in charge of the Machine Shop unit.

RICHARD K. WEST, head of West Instrument enterprise, was lost December 20 while flying his company plane over Lake Erie.

Prominent in the development of the firm bearing his family name, West was president of West Instrument Corp., Chicago, and chairman of West Instrument, Ltd., England.

Associated in these enterprises are his father and brother, William C. West, Sr. and Jr. It is understood that both are continuing operations under authority of directors.

West was also head of all Naval Reserve activities at Glenview, Ill., Naval Air Base, and was president of the Naval Reserve Association for 1957.

ATLAS POWDER CO. has announced the establishment of a Toxicoligy section in its Chemical Research department to carry out research on the safety of Atlas products from the standpoint of handling, use, and consumption. Previously, these investigations have been performed solely by leading colleges and research institutions on a contract basis, and some of this work will be continued.

Dr. Joseph F. Treon, who joined Atlas last May from the Kettering Laboratory of the University of Cincinnati's College of Medicine, has been named to head the new section.

Treon

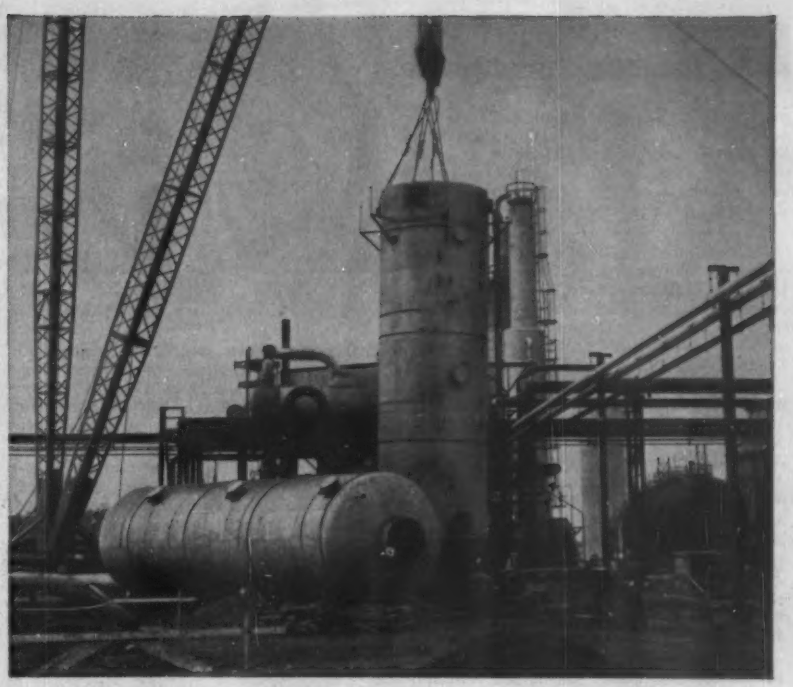
Dr. Treon, a native of Aurora, Ind., received a B.S. degree in chemistry from Indiana University in 1930. He received his Ph.D. degree in chemistry from the University of Cincinnati in 1935, entering the Kettering Laboratory thereafter spending one year in industry as a technical advisor.

Dr. W. H. C. Rueggeberg, director of the department, said the decision to set up internal laboratory facilities and staff was made because of the increasing use of chemical products in foods, cosmetics, and other consumer products.

CALUMET & HECLA, INC. has announced completion of the first of four major expansion projects undertaken by its Wolverine Tube Division. **D. W. Blend,** vice president and general manager of the division, made the announcement.

Executive offices formerly located at the Detroit plant, and sales department offices formerly located in the Guardian Tower Building in Detroit are now centralized in a single-story air conditioned building.

"We are bringing all our Division sales and administrative people together to eliminate lost motion, to cut costs, and to im-



More than 86,680 welds in complex column by Downingtown

Diameter: 11′ 11″ I.D.

Total Height: 93′ 11″.

Material: Stainless steel, Type 304. Carbon steel skirt and base ring.

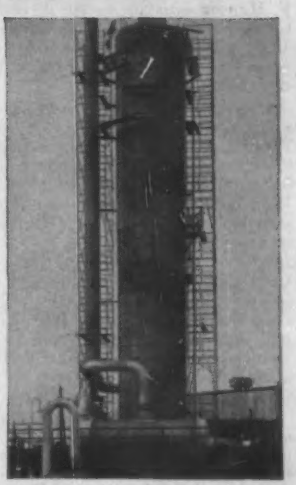
Shell Thickness: ½″ and ⅜″.

40 Trays and downcomers. 177 bubble caps and risers on each tray.

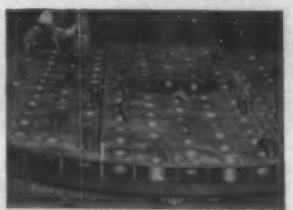
Code Stamping: National Board and ASME. Sandblasted and pickle washed.

Downingtown welders completed more than 86,680 separate stainless steel welds during fabrication of this stainless steel column. Tolerances of ±⅛″ . . . ±1/16″ . . . even ±1/32″ . . . were maintained in the shaping, positioning and welding of thousands of stainless steel parts. Lapsed time from drawing board to final field testing: less than six months.

Send for Bulletin PF. It tells the story of Downingtown skill and experience that enable us to breeze through complex fabrication jobs like this one.



Field tested by Downingtown... inspected by customer and Hartford...Code stamped on location.



Special jig for welding stainless steel risers to stainless steel tray.

Downingtown Iron Works, Inc.

151 Wallace Ave., Downingtown, Pennsylvania

division of PRESSED STEEL TANK COMPANY Milwaukee

Branch offices in principal cities

HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

prove our ability to compete," Mr. Blend said. "We think we have the experience, the people, and now the facilities to grow at a rapid rate." A separate structure provides modern facilities for Wolverine's New Products Division.

Three other projects rapidly nearing completion include expansion of fabricating and manufacturing facilities at the Decatur, Alabama, plant; $4,000,000 modernization of the 50-year-old plant in Detroit, including installation of unique tube mill equipment; and construction of a new $7,000,000 plant in London, Ontario.

ROCKWELL MANUFACTURING CO.'S new 180,000-square-foot plant at Kearney, Neb., is now in limited production, **Lloyd A. Dixon Jr.**, vice president in charge of Meter and Valve Division, has announced. Approximately 75 employees are already at work.

The new plant, which cost more than $2 million, is a one-story brick and tile structure located on a 52-acre plot. The plant has as general manager, **Weldon D. Willes**, who is also assistant to the president of Rockwell's LFM Division.

BORG-WARNER CORP. has named **Rudolph F. Hanson** assistant to the director of sales of materials handling equipment for the Ingersoll Kalamazoo Division. The announcement was made by **David H. Cissna**, director of sales.

Hanson graduated from Western Michigan University. In 1953 he joined Harvey Paper Co., Sturgis, Mich., a subsidiary of KVP, as a sales correspondent. He joined Ingersoll Kalamazoo division in March of 1956 as a sales coordinator. He will be responsible for assisting the director of sales in all sales activities.

GULF OIL CORP. has announced the opening of a petrochemicals sales office in the Gulf Building, Houston. **John T. McDonnell** has been transferred to Houston where he will represent Gulf's petrochemical marketing interests in the Gulf Coast area.

A native of Tulsa and a chemical engineering graduate of Oklahoma University, McDonnell was formerly with Warren Petroleum Corp. and has been engaged in research and sales of Petrochemicals and natural gasoline since 1946.

UNITED STATES STEEL CORP. has appointed **Gene H. Stumpf** field representative of its Oil Well Supply division at Fort Morgan, Colo. Stumpf was employed by Oilwell in 1954 at Fort Morgan. A native of Colorado, he served in the U. S. Air Force during the Korean Conflict.

MINNEAPOLIS-HONEYWELL REGULATOR CO. has announced completion of enlargement of production and engineering facilities of the Heiland division, Denver, it was reported by **S. A. Keller**, general manager. The firm has added an additonal 12,000 square feet to its present plant area to expand production of its line of oscillographic instruments.

The addition of the new space is the second major physical expansion for the firm within two years. It moved into its new $1-million one-story plant, located on a nine-acre plot in Arapahoe County on the outskirts of Denver, in December 1955.

Frink

Walter

CALUMET & HECLA, INC.'S, Wolverine Tube division has established a separate New Products division and an Operations division, it was announced by **D. W. Blend**, vice president and general manager of Wolverine Tube.

R. M. Frink has been named to the newly created post of director, new products division, and **E. C. Walter** was named director of operations. Previously, research and development was the responsibility of the former Operations Control division, directed by Frink.

Frink has been with Wolverine Tube since 1939, except for five years military service. He has worked in every phase of plant activities starting with production jobs in the mill through plant manager, customer relations and director of operations. Prior to joining Wolverine, he had varied experience in sales, engineering and auditing and was also in his own business.

Before joining Wolverine Tube in 1954, Walter was vice president and general manager of Viking Copper Tube Co. for five years. Prior to that, he was with Chase Brass & Copper Co., Inc., for eleven years in various engineering capacities. Walter is a 1937 graduate of Case Institute of Technology with a B.S. degree in metallurgy.

FLUOR PRODUCTS CO., Whittier, Calif., has signed an agreement with **Maschinenfabrik Hartmann A. G.,** Offenbach, Germany, to design, manufacture and sell the German firm's complete line of heavy duty industrial pneumatic and mechanical conveying systems, ash handling systems, dust removal and classifying systems.

In line with the agreement, Fluor has established a new division, Fluor-Hartmann, headed by **James Elizardi**, formerly vice president Mid-Continent sales area.

DRESSER INDUSTRIES has promoted R. E. Reimer to executive vice-president, he will also continue to serve as Dresser's treasurer. **John Lawrence** was also named as an executive vice president. **Thomas L. Moody** was appointed vice president in charge of Industrial Relations. **J. Douglas Mayson** succeeded Reimer as secretary and **Cecil C. Hill** and **Paul E. Brodrick**, were made assistant treasurers.

Reimer has been with Dresser since 1929. In 1947 he was elected vice president and continued to hold the other offices of secretary and treasurer. In November, 1956, Reimer was elected to Dresser's board of directors.

Lawrence, a new Dresser official, recently resigned as president of Joy Manufacturing Co., to join Dresser's organization as a vice president. He brings to Dresser a background of 25 years' experience in varied manufacturing and engineering practices, and wide experience in the mining and construction equipment fields.

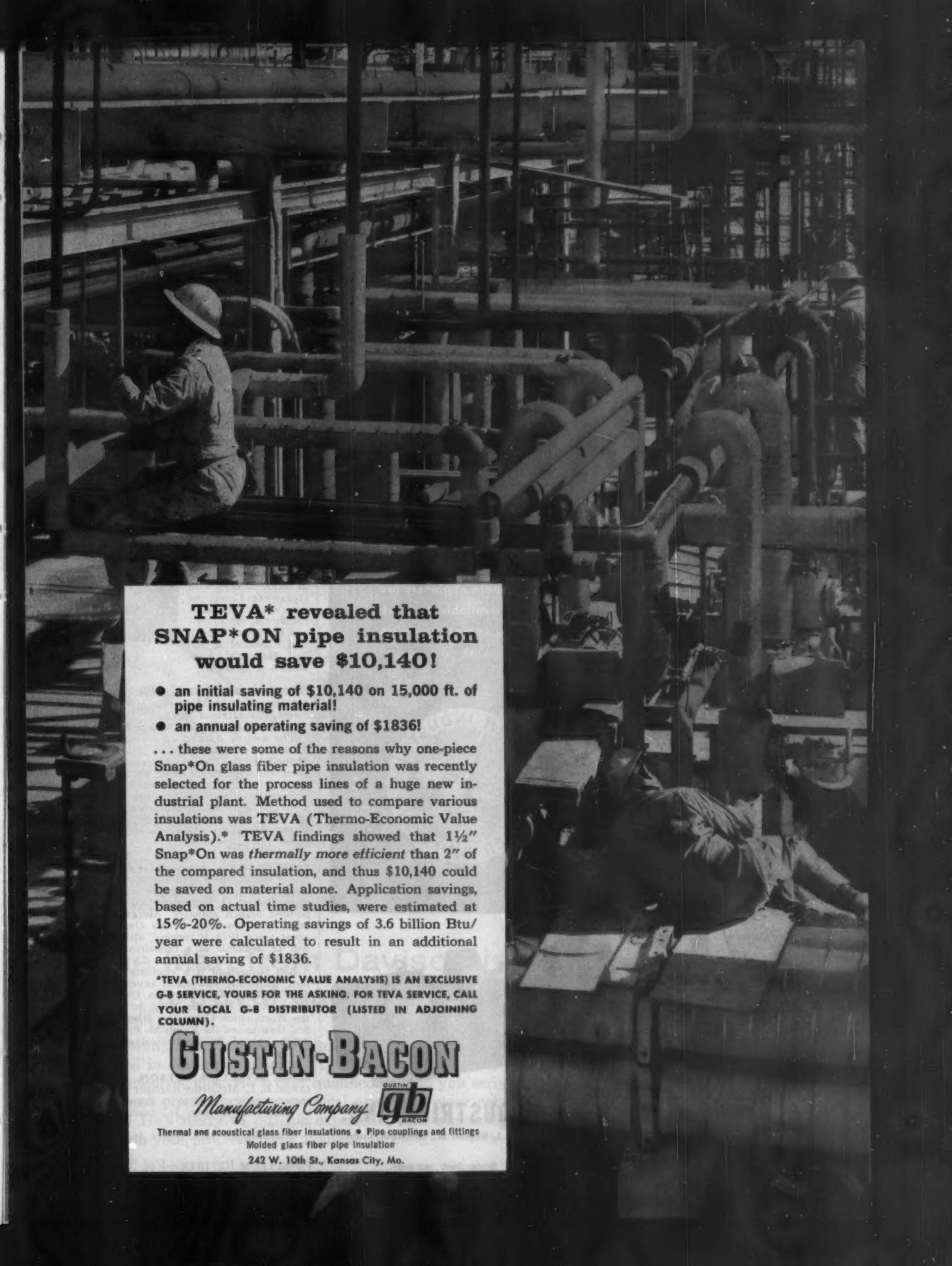
Thomas L. Moody moves into a vice

G-B SNAP* ON DISTRIBUTORS

(See ad on facing page)

ALBUQUERQUE, Mt. States Insulation Co.
AMARILLO, Ball Distributing & Engr. Co.
ATLANTA, Ga., Reynolds Aluminum Supply Co.
BALTIMORE, Md., Leroy Insulation Co.
BILLINGS, Mont., Big Horn Supply, Inc.
BIRMINGHAM, Ala., Shook & Fletcher Supply
Reynolds Aluminum Supply Co.
BROOKLINE, Mass., Homans-Kohler, Inc.
BUFFALO, Industrial Insulation Sales, Inc.
CHARLESTON, W. Va., Baldwin Asbestos Products Co.
CHARLESTON HEIGHTS, S. C., Stafford Insulation Co.
CHARLOTTE, N. C., Guy M. Beaty & Co.
CHATTANOOGA, Guy M. Beaty & Co.
CHICAGO, E. C. Carlson Co.
CINCINNATI, R. E. Kramig & Co.
CLEVELAND, The Miles Materials Co.
COLUMBUS, Santeler Brothers
DALLAS, Insulation Supply Co., Inc.
DAVENPORT, Republic Electric Co.
DENVER, Gene Wright Lumber Co.
DES MOINES, Iowa Asbestos Co.
DETROIT, Coon DeVisser Co.
EL PASO, Insulation & Specialties Co.
FARGO, N. D., Smith, Inc.
FT. SMITH, Ark., Gunn Distributing Co.
FT. WAYNE, Ind., M. H. Hilt, Inc.
FT. WORTH, The Bracken Co.
GREENSBORO, N. C., Starr Davis Co., Inc.
GULFPORT, Miss., Paine Supply Co.
HOUSTON, Precision Insulation Co.
INDIANAPOLIS, Central Supply Co.
JACKSON, Miss., Paine Refrigeration & Supply Co.
JOPLIN, Mo., Joplin Cement Co.
KANSAS CITY, Kelley Asbestos Co.
LITTLE ROCK, Gunn Distributing Co.
LOS ANGELES, Western Fibrous Glass Products
Thorpe Insulation Co.
LOUISVILLE, General Insulation & Roofing Co.
MEMPHIS, John A. Denie's Sons Co.
MIAMI, Reynolds Aluminum Supply Co.
MILWAUKEE, F. R. Dengel Co.
MINNEAPOLIS, Asbestos Products, Inc.
MOBILE, Ala., Shook & Fletcher, Inc.
NASHVILLE, Reynolds Aluminum Supply Co.
NEWARK, N. J., Eastern Steam Specialty Co.
NEW HAVEN, Conn., Insulation Supply Co.
NEW ORLEANS, Eagle Asbestos & Packing
NEW YORK, Eastern Steam Specialty Co.
OKLAHOMA CITY, Ball Distributing & Engineering Co.
OMAHA. Cardinal Supply & Mfg. Co.
PHILADELPHIA, John F. Scanlan, Inc.
PITTSBURGH. Dravo Corp.
PHOENIX, Ariz., Kircher Asbestos & Rubber Co.
RALEIGH, N. C., Reynolds Aluminum Supply Co.
RICHMOND, Va., Reynolds Aluminum Supply Co.
ROCKFORD, Ill., Mott Brothers Co.
SALT LAKE CITY, Bullough Asbestos Supply Co.
SAN ANTONIO, The Bracken Co.
SAN DIEGO. Western Fibrous Glass Products
SAN FRANCISCO, Western Fibrous Glass Products
SAVANNAH, Ga., Reynolds Aluminum Supply Co.
SEATTLE, Western Fibrous Glass Products
SOMERVILLE, Mass., Thermal Insulation Co.
SOUTH BELOIT, Ill., Mott Brothers Co.
ST. LOUIS, The Brauer Supply Co.
The Stovey Company, Inc.
ST. PAUL, Asbestos Products, Inc.
SYRACUSE, N. Y., Industrial Supply Co.
TAMPA, Fla., Eagle Roofing & Art Metal Works, Inc.
TALLAHASSEE, Fla., Bakers, Inc.
TULSA, Okla., Ball Distributing & Engr Co.
TUPELO, Miss., Paine Supply Co.
WASHINGTON. Walter E. Campbell Co., Inc.
WICHITA, Jamar-Olmen Construction
VANCOUVER, B. C., Fleck Brothers Limited

GUSTIN gb BACON



TEVA* revealed that SNAP*ON pipe insulation would save $10,140!

- an initial saving of $10,140 on 15,000 ft. of pipe insulating material!
- an annual operating saving of $1836!

. . . these were some of the reasons why one-piece Snap*On glass fiber pipe insulation was recently selected for the process lines of a huge new industrial plant. Method used to compare various insulations was TEVA (Thermo-Economic Value Analysis).* TEVA findings showed that 1½" Snap*On was *thermally more efficient* than 2" of the compared insulation, and thus $10,140 could be saved on material alone. Application savings, based on actual time studies, were estimated at 15%-20%. Operating savings of 3.6 billion Btu/year were calculated to result in an additional annual saving of $1836.

*TEVA (THERMO-ECONOMIC VALUE ANALYSIS) IS AN EXCLUSIVE G-B SERVICE, YOURS FOR THE ASKING. FOR TEVA SERVICE, CALL YOUR LOCAL G-B DISTRIBUTOR (LISTED IN ADJOINING COLUMN).

GUSTIN-BACON

Manufacturing Company GUSTIN gb BACON

Thermal and acoustical glass fiber insulations • Pipe couplings and fittings
Molded glass fiber pipe insulation
242 W. 10th St., Kansas City, Mo.

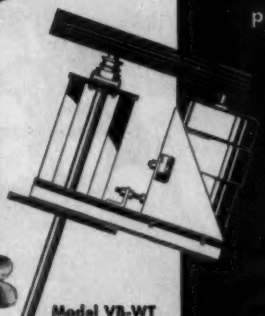
SOLVE YOUR MIXING PROBLEMS

Series C
Side Entering Mixer

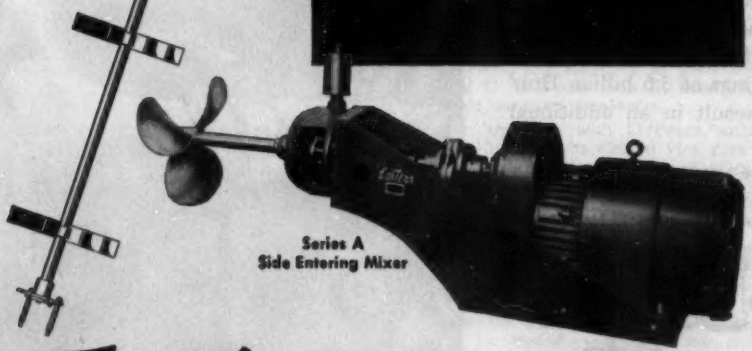
Series C
Top Entering Mixer

A tremendous variety of fluid mixing needs are ably handled by the complete line of Eastern Mixers. Size and power of mixers are flexible to help solve your problems. For complete information and engineering data, write for Eastern Fluid Mixing Catalogs. Eastern engineers are always available to work out your complex mixing problems with you.

EASTERN INDUSTRIES ★ MIXER DIVISION ★



Model VB-WT
Turbine Mixer



Series A
Side Entering Mixer

Eastern INDUSTRIES, INC.
Dept. L, Regent St., Norwalk, Conn.

Suppliers . . .

presidency after fifteen years as director of industrial relations. Moody completed undergraduate work at the University of Georgia in 1928 with a B.S. degree. He also holds an LLB degree.

Mayson, the new secretary, moved up from his post as assistant secretary to which he was appointed in April 1957. He joined Dresser in 1944 as tax attorney and was named director of Dresser's legal department in 1949.

Hill, recently was called to Dallas to join the home office top management group of Dresser on special assignments after fifteen years with Clark Bros. Co., Olean, N. Y., a Dresser subsidiary. Hill was controller of Clark from 1942-1953 and secretary-treasurer from 1953-1957.

Since joining Dresser in 1945 Paul Brodrick has served as assistant controller and at present is director of shareholder relations. Before joining Dresser, he was with National Tube Co. in special financial assignments.

TRULAND CHEMICAL CO., INC., division of the Trubek Laboratories, East Rutherford, N. J., has appointed **John N. Adsit** to the sales department. His activities will include a broad range of customer contact as well as the acquisition of raw materials.

Adsit

Adsit was formerly in technical sales with Celanese Corp. of America. He is a member of the American Chemical Society and Chemical & Allied Industries Association of Detroit.

OAKITE PRODUCTS, INC., technical service representative in Minneapolis, **Walter C. Sweet,** has received the 1957 D. C. Ball Award for Distinguished Oakite Service.

The award, named in honor of the founder of Oakite Products, Inc., is given annually to the Oakite representative who "best carries forward with his customers the highest ideals of Oakite service."

Sweet, who was selected from the company's 227-man field organization, received the award from **John A. Carter,** president, at Oakite's recent sales conference in Chicago.

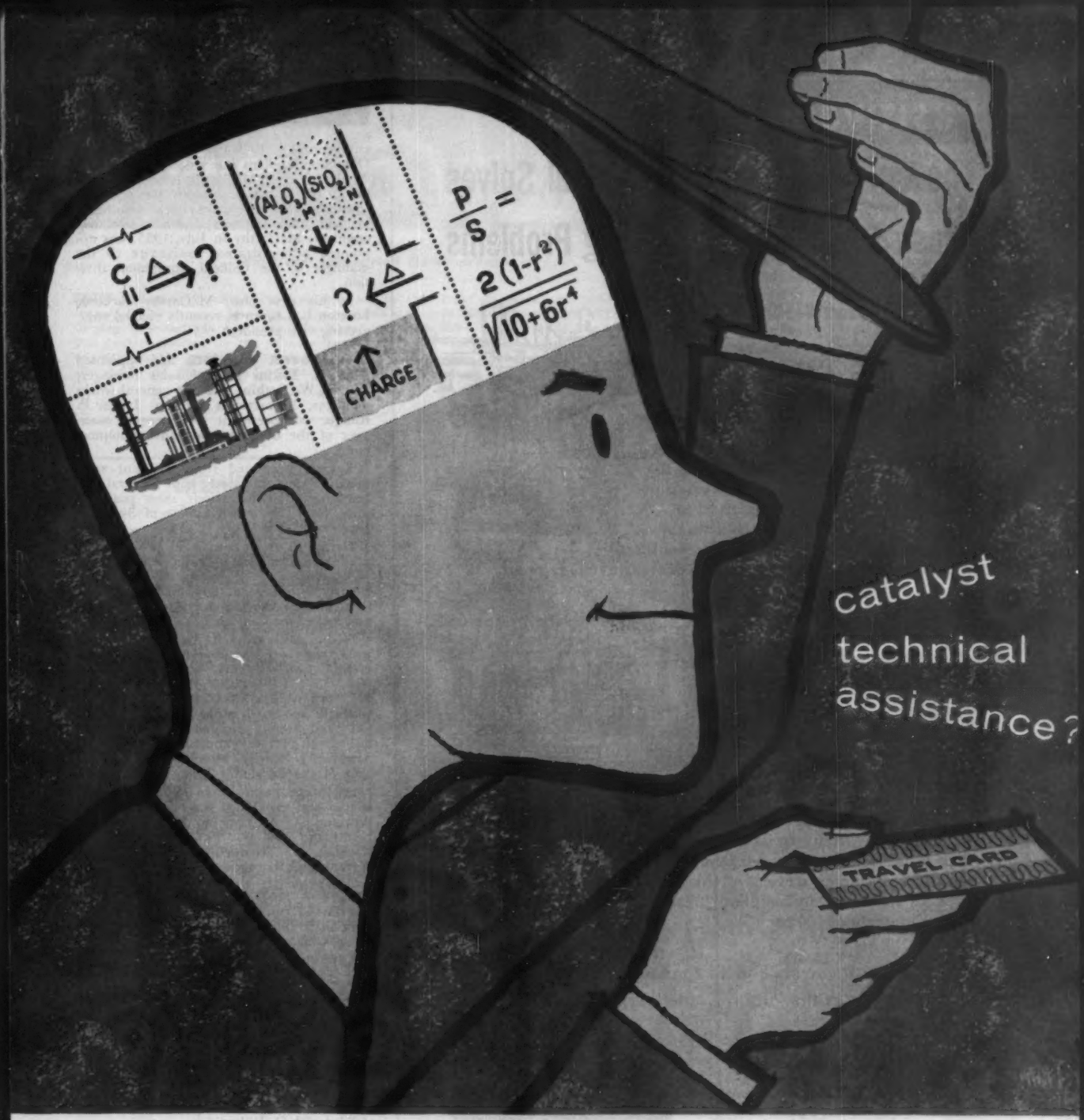
C. LEE COOK CO., Louisville, a division of Dover Corp., announced the opening of a branch office and warehouse in Los Angeles. **Robert D. Sutherland** has been appointed branch manager. **Morgan Washburn,** who has been Cook's California agent since 1928 is retiring, although he will be available as a consultant for the company.

Bob Sutherland is a graduate of Stanford University and spent several years with Ingersoll-Rand prior to 1942. After his discharge from the Navy, he was with the Worthington Corp. as a sales engineer and then joined the Ralph M. Parsons Co. in charge of the mechanical equipment section.

BLACK, SIVALLS & BRYSON, INC., has named **E. L. McCarthy** manager of oilfield engineering according to an announcement by **Henry A. Ruysser, Jr.,** executive vice president.

Obtaining his M.S. degree in chemical

For more data on advertised products, use Readers' Service Cards, last page.



The Man from Davison is quick with a travel card, quick with your answer

The Man from Davison will go anywhere any time. He's worked in advisory capacity on hundreds of complex petroleum catalyst jobs. He is best qualified to help you arrive at the most practical and economical answer to your catalyst needs. He's ready to put his experience and knowledge to work on your problem. He's available at once.

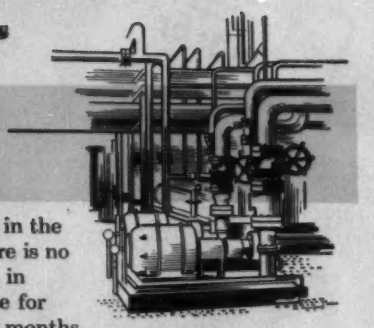
DAVISON
CHEMICAL COMPANY
Division of W. R. Grace & Co.
Baltimore 3, Maryland

Buy DAVISON—the quality catalyst backed up by experience, research, technical assistance, service!

Positive Proof...

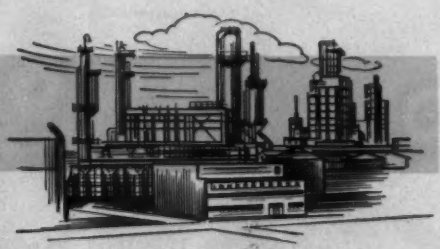
The John Crane® Type 9 Shaft Seal Solves Those Tough Liquid Handling Problems

Actual Field Reports



✓ from an Arkansas Refining Plant

When it comes to avoiding trouble in the handling of naphtha at 420°F., there is no substitute for positive sealing. And in cases like this there is no substitute for "John Crane's" Type 9 Seal. Many months of completely satisfactory operation offers convincing proof.

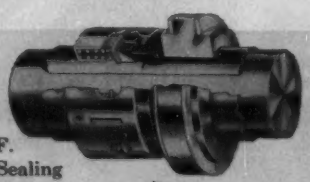


✓ from a Louisiana Refinery

It takes a "lot of shaft seal" to handle a highly corrosive mixture such as an emulsion of sulphuric acid and butane. This stuff plays real havoc with metals due to its corrosive action. Despite this, Type 9 Seals on twenty seven pumps are pumping month after month in continuous service. At this same location, other Type 9's are effectively handling "fresh" sulphuric acid at the high suction pressure of 400 psi.

In cases like these . . . and in those confronting you . . . the surest answer is the "John Crane" Type 9 Seal.

CONDENSED SPECIFICATIONS



Recommended services: all industrial chemicals, corrosives, liquids or gases. Temperatures: −120°F. to +500°F. Pressures: up to 750 psi. Construction: Sealing members of chemically inert DuPont Teflon, metallurgy best suited to service requirements.

Send us your problems. Request Bulletin S-205-2.

Crane Packing Company, 6420 Oakton Street, Morton Grove, Illinois, (Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

CRANE PACKING COMPANY

Suppliers . . .

engineering in 1949 from the University of Oklahoma and his B.S. degree from Texas A & I in 1948, McCarthy joined BS&B in late 1949. Serving through the years as research engineer, engineering section head, assistant chief engineer, and administrative engineer, McCarthy in July, 1955, was appointed administrative assistant to the manager of the Oilfield Equipment division.

In his new post, McCarthy succeeds **Lawton L. Laurence**, recently elected engineering vice president.

H. K. PORTER CO., INC., has appointed **Alan R. Eakins** general sales manager, and **H. W. Gethin**, assistant general works manager, Refractories division. **James P. Raugh**, vice-president and general manager of the division made the announcement.

Eakins, promoted from assistant sales manager, was previously with General Refractories Co. in various sales positions since 1949. He is a graduate of Syracuse University, New York.

Gethin is a ceramic engineer and graduated from Penn State University in 1930. He has been with Porter's Lacledé-Christy Works since 1944, and previous to that, had 14 years of refractories production experience.

Gethin will assist **E. G. Platt**, general works manager, in supervising production of refractory products.

UNITED STATES STEEL CORP. has appointed **Clifford W. Snell**, store manager of the Oil Well Supply division store at Blanding, Utah, it was announced by **R. L. Armstrong**, Rocky Mountain area manager of the division.

Snell was employed in 1954 at Powell, Wyo., and in 1955 was transferred to Worland, Wyo. Prior to his present appointment Snell was located at Williston, N. Dak. He attended the University of Wyoming at Laramie.

KEASBY & MATTISON CO. has promoted **Charles C. Sprangers** to manager of the company's building materials department in its Chicago office. The announcement was made by **D. W. Frasier**, Chicago district manager.

The new manager joined K & M in 1950 as a salesman after having been associated with the U. S. Gypsum Co. as a research assistant. He is a graduate of St. Johns College Preparatory, Collegeville, Minn.

NORTON CO. has appointed **Hugh A. Allen** traffic manager following the retirement of **Frederick D. Wilson.**

Frederick A. Anderson assumed a newly created post as traffic rate specialist. Both Allen and Anderson will report to **J. Douglas Dawson**, general traffic manager.

In two other appointments, **William H. Silvester, Jr.** became supervisor of traffic for the Grinding Machine division, and **Frederick W. Lester** became supervisor of the bill of lading section for all domestic traffic except grinding machines.

Allen has been a member of the Traffic Department since 1923 when he began as a clerk and driver of the department car. In 1942 he was appointed assistant traffic manager of the Grinding Machine division and in 1946 he became traffic manager of the division.

For more data on advertised products, use Readers' Service Cards, last page.

Petroleum Refiner Classified Ads

Petroleum Refiner New Classified Rates

RATES: **Regular Classified** (undisplayed) **set in this type: 20 cents per word. Minimum charge, $4. Blind box address in our care counts six words. Replies forwarded without charge. Display Classified ads, set in suitably larger type with ruled border, $12.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. All Classified ads payable in advance. Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston, Texas.**

* * * * * * * * * * * * * * * * *

HELP WANTED

CHEMICAL and MECHANICAL ENGINEERS

A large and expanding international petroleum company has openings for several Chemical and Mechanical Engineers with outstanding ability. This is a challenging opportunity to share the responsibility of coordinating international refining operations. Excellent advancement opportunities for applicants with a minimum of 3 years petroleum or chemical industry experience. Immediate assignment to our Far East refineries or to our White Plains Headquarters with an eventual overseas assignment. Salary commensurate with experience, liberal annuity, insurance, hospitalization and savings plans. Will pay moving and transportation expense. Please send resume to:

DENNIS V. WARD
STANDARD-VACUUM OIL COMPANY
P. O. BOX 1000
WHITE PLAINS, N. Y.

CHIEF PROCESS & DESIGN ENGINEER

for

Gas Processing and Oil Refinery Operations

Canadians Note—Unusual opportunity for supervisory engineer with young, growing, integrated Canadian oil company. Should have 10 years experience in plant process and design engineering.

Write: Box No. 281-R,
PETROLEUM REFINER
Houston, Texas

HELP WANTED

PROCESS & DEVELOPMENT ENGINEERS

FOR

- **Design**
- **Equipment specification**
- **Methods and data**

at

FLUOR

. . . recognized as one of the leading, internationally known engineering and construction firms serving the petroleum, chemical and power industries.

●

Located In Southern California

FLUOR

Offers experienced men maximum opportunities for:
Utilization and recognition of individual initiative and ability.
Broad responsibilities rather than narrow specialization.
Experience with a wide range of processes

●

Liberal salary ranges, Profit sharing, Top benefits, and ideal working conditions.
Submit resume of training and experience to:

THE
FLUOR
CORPORATION, LTD.
ENGINEERS — CONSTRUCTORS
2500 S. Atlantic Blvd.
Los Angeles 22, Calif.

WANTED

Sales engineering group, Houston, Texas, interested in product or equipment for pipeline and petro-chemical industry. Could use product requiring some field engineering and/or modification. Have available yard storage, warehouse, some metal fabricating facilities. Adequately staffed and financed. Box #283-R, Petroleum Refiner, Houston, Texas.

WANTED

Propane Deasphalting Plant Approximately 1000 B/D Capacity.

Box 284-R, PETROLEUM REFINER, Houston, Texas

HELP WANTED

Assistant Department Manager

Company located in the Mississippi Valley has an immediate opening for an Assistant Manager in its Ammonia Department. Individual should possess a BSChE Degree and have 3 to 8 years supervisory production experience, coupled with potential for promotion to Department Manager.

State education, experience, and salary history and requirement in first letter to:

Box 285-R
PETROLEUM REFINER
P. O. Box 2608 • Houston, Texas

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INFORMATION UNLIMITED—Read MONITOR—easiest, quickest way to keep pace with fast-moving oil industry. Specialists abstract articles from more than 100 petroleum publications of 11 countries. Executives, engineers, geologists, researchers; keep informed on engineering techniques and news in your field—subscribe now to this bi-monthly magazine. Major oil companies approve. One year, $7.50 (foreign $8.00). Request free copy. MONITOR Box 476-F, Dallas 21, Texas.

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If You Want

Fast

Results . . .

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Petroleum

Refiner

Classified Ads

For more data on advertised products, use Readers' Service Cards, last page.

What's New in Equipment . . .

. . . and Manufacturers Literature

FIGURE 1—Tungsten carbide insert shows little wear. Chip caused by heavy object passing through the valve.

FIGURE 2—No wear on this hard faced valve, only a catalyst impingement ring.

Hard Facing Stops Catalytic Erosion

Based on data correlated to date by Atlantic Refining Co., tungsten carbide seems to be the material answer to catalytic erosion.

Company engineers base their conclusions on the results and condition of slide valves after a year's run on a fluid catalyst unit.

Ever since the introduction of fluid catalytic cracking units in the petroleum industry, slide valves controlling the flow of catalyst have been one of the weakest operational points in the process. The reason: The erosive characteristics of the catalyst.

Investigation of the problem in Atlantic's research and development department began as far back as 1947 as the erosive problem became more acute. But up until the fall of 1948, the problem was still unsolved, and remained unsolved until recently when an eight-inch slide valve in the Cottrell precipitator failed, causing an emergency shutdown of the unit.

Before the emergency shutdown Atlantic engineers were experimenting with Carboloy grade 883 carbide inserts about 9¾ x 6 x ⅝-inch for a 24-inch slide valve.

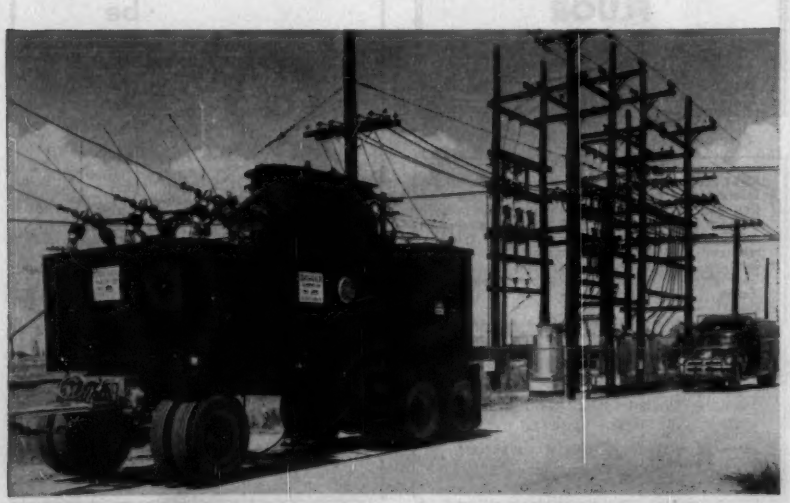
Figure 1 shows the condition of the large insert after being installed in the fluid catalytic cracking unit for a year. As can be seen, there was very little wear on the carbide insert while the section next to the insert was eroded considerably.

The 8-inch slide valve which failed later was a regular carbon steel valve shown in Figure 2. Upon failure of the 8-inch slide valve, it was decided to face the valve with Carboloy grade 883 carbide, lining the valve throat with Carboloy grade 55A carbide.

When the valve was removed after being in operation for a year, there was very little wear on the carbide face, and no noticeable wear on the throat liner. There was, however, a light ring on the face of the slide valve caused by catalyst impringement when the valve was closed, as shown in Figure 2. Although the slide was ground for re-use, it could have been used for another run without regrinding.

Cost of facing and lining the 8-inch slide valve was $2019, relatively inexpensive when compared to the cost of an emergency shutdown. General Electric Co.

Circle E1 green card, last page



Mobile Substation Used For Maintenance Work

A trailer-mounted substation, containing in one package a transformer, switchgear, and lightning arresters, can be hauled anywhere in Gulf's four-square-mile Port Arthur refinery area to take over for transformer banks or substations that must be taken out of service for maintenance.

The refinery generates its own electricity and operates its own transmission and distribution system. It has three power plants with a total capacity of about 70,000 kw, and more than 140 transformer banks or substations, ranging from 5,000 kva downward.

The mobile unit can be used in five different ways:

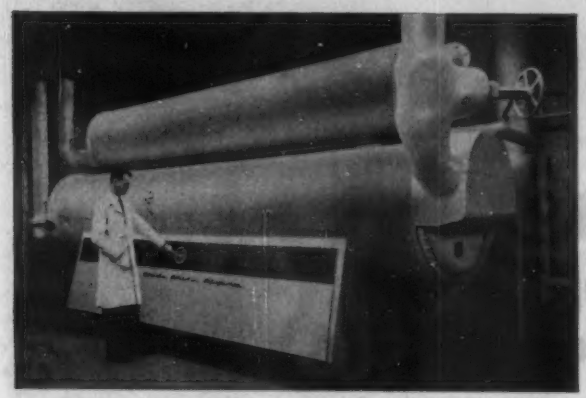
Incoming circuit	Outgoing circuit	Substation capacity
13,800 v delta	2,400 v delta	3,000 kva
13,800 v delta	480 v delta	1,500 kva
13,800 v delta	480Y/277 v	867 kva
2,400 v delta	480 v delta	1,500 kva
2,400 v delta	480Y/277 v	867 kva

The mobile unit is being used for

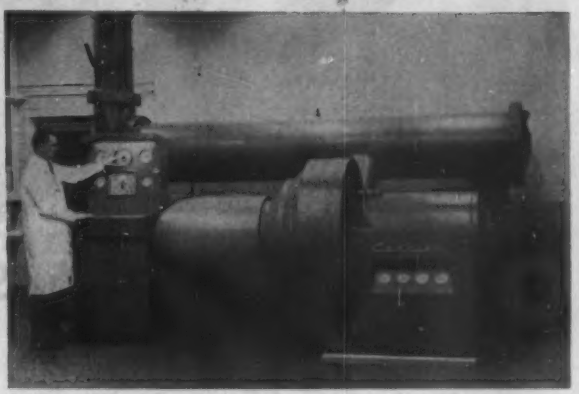
Which is the best refrigerating machine for petroleum processing?

That depends upon your requirements and your source of energy—whether your load is large or small, whether you use low-cost steam or electricity. There is one best type of refrigerating machine for every problem—and Carrier makes them all. They are described below. So the only interest of your Carrier specialist is to recommend the type that serves you best. Throughout the world, in hundreds of dependable installations, Carrier has been serving the petroleum industry with refrigeration equipment and air and gas compressors. Take advantage of this wealth of experience to get the best refrigerating machine for your needs. Call your nearest Carrier office. Or write Carrier Corporation, Syracuse, New York.

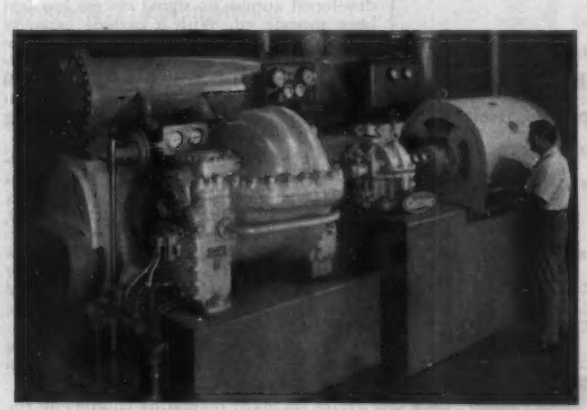
Carrier



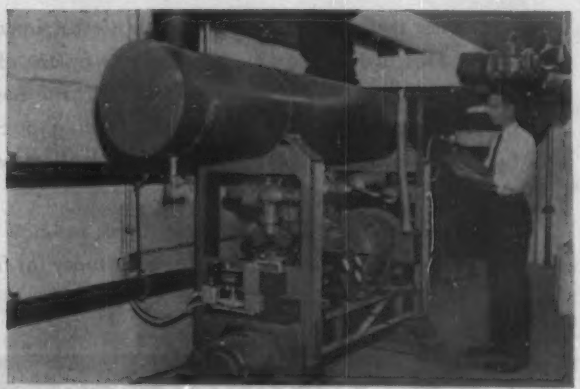
If you have low-cost steam, Carrier's new Absorption Refrigeration Machines may be best. They use heat energy from low-pressure steam, hot water, hot petroleum or other solutions. They're dependable, efficient. Operation is automatic and quiet. Cooling capacities: 60 to 700 tons.



If you have low-cost electricity, new Hermetic Centrifugal Refrigeration may be the answer. Compactness and light weight minimize space and structural requirements. Electronic controls provide continuous, automatic chilling of water to the desired temperature. From 90 to 1100 tons.



If the load is large, Carrier Centrifugal Refrigerating Machines may be best. With capacities to 4000 tons, they can serve the largest applications with accurate, automatic control of temperature 24 hours a day, year around. Extremely versatile, they can be used for many processes.



If the load is small, Carrier Reciprocating Water Cooling Machines may be ideal. They're completely "packaged." Installation costs are lower and operation more efficient than units assembled from unrelated components. Their cooling capacities range from 3 to 200 tons.

For more data on advertised products, use Readers' Service Cards, last page.

New Equipment . . .

planned maintenance work on refinery substations and transformer banks up to 3,000 kva.

The 480Y/277 v connection is required only to protect service to a large warehouse for shipping packaged products. Warehouse lighting is served by a 13,800 v/ 480Y/277 v transformer. The warehouse covers more than six acres and cannot be operated without lights. General Electric Co.

Circle E2 green card, last page

Inertia Switch Protects Machines From Vibration

An "inertia switch," an automatic device that is actuated by thrusts, impacts or excessive vibrations has now been developed.

Originally designed for aircraft and missile uses, such as in emergency lighting and fire extinguisher operation, the new switch provides full-time, low-cost protection for unattended industrial equipment. For example, if unusual vibrations occur, the inertia switch senses the troubles, shuts off the machine, or sounds an alarm. In this way, isolated fans, compressors and other machinery may be continuously protected.

Once actuated, the switch will remain operated and cannot be jarred back into an unactuated position. The reset the switch, a manual reset button is provided. Electrical reset may also be provided.

The switch operates when subjected to a thrust in any horizontal direction. Micro Switch Division of Minneapolis-Honeywell Regulator Co.

Cricle E3 green card, last page

Here's Real Proof of the Superiority of Hartzite Plastic Cooling Tower Fans

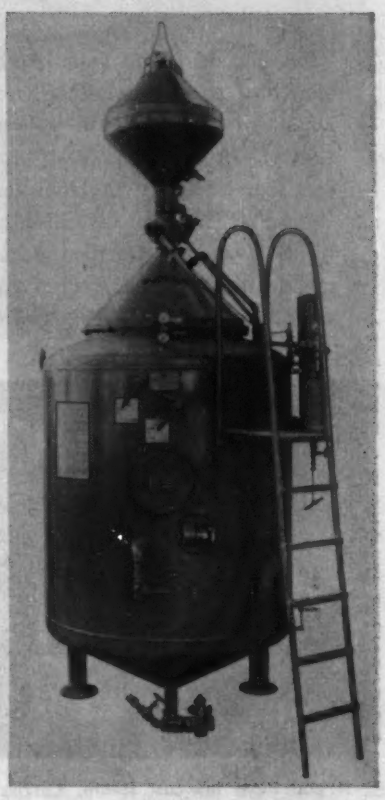
Since Hartzite plastic was introduced in 1941, one leading producer of petroleum products* has purchased 411 Hartzell cooling tower fans with Hartzite plastic blades. This figure does not include the additional units supplied to this customer by the cooling tower manufacturers who use Hartzell fans on their towers.

What better proof could you ask of the superiority of Hartzite plastic fans than this complete acceptance by one of the largest users of such equipment. Beyond all doubt, Hartzite has proved itself to this customer and to thousands of other cooling tower operators as the fan blade material most resistant to vibration, corrosion, abrasion and mechanical damage.

For complete details on Hartzell fans, and how they can help you cut cooling tower maintenance costs, write today for free Bulletin A-111 or call your nearby Hartzell field engineer.

*Name on request.

HARTZELL Propeller Fan Co.
Division of Castle Hills Corp.
909 Thomas Blvd. Piqua, Ohio



Acetylene Generator Has Automatic Danger Signals

This acetylene generator with a newly-developed automatic signal system has just been introduced. With a carbide capacity of 500 pounds, the MP-11 will produce 1000 cubic feet of medium-pressure acetylene per hour. Delivery rates of up to 2000 cubic feet of acetylene per hour are obtainable over shorter intermittent operating periods.

The new automatic signal system consists of a howler and indicator lights that provide both audible and visual warning if minimum carbide supply, water level, or water temperature should deviate from normal. Three independent circuits make up the signal system so that the generator can be equipped with any combination of audible or visual signals for these three conditions. The unique signal system notifies the operator of abnormal conditions even if he is a considerable distance from the generator building.

With standard regulating equipment, the MP-11 generator can also be used to supply low-pressure acetylene to a piping system. Continuous operation reduces the number of generators needed in multiple generator installations and makes it possible for a single MP-11 to be used in place

ONE ORDER

fills all your laboratory chemical needs at B&A

Simplify your buying and bookkeeping. Order *all* your laboratory chemical requirements from B&A's complete line—readily available from our coast-to-coast chain of warehouses, and from 35 leading laboratory supply houses. Here's convenient, dependable "one-stop shopping." Plus the advantages of dealing with the country's foremost producer of laboratory and scientific chemicals—the leader in purity . . . in packaging for safety and convenience . . . in development of new and improved products . . . and in service.

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The most complete, most preferred line in the country. B&A offers over 1,000 high-purity reagents to meet your every need. Outstanding for packaging, too!

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Widest possible selection from America's pioneer producer. More than 50 Acids are available in all preferred grades and strengths to fill every laboratory requirement.

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B&A's extensive line includes organic and inorganic radioisotopes, including Carbon-14 labeled compounds and deuterated compounds.

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B&A regularly offers over 30 rare earth oxides and salts in experimental and commercial quantities. Others available on request.

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The complete line of Eastman Organic Chemicals as listed by Eastman Kodak Company is always available from B&A.

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And, to round out its service, B&A provides the full line of "National Quality" Stains and Indicators of Allied Chemical's National Aniline Division.

BAKER & ADAMSON®
Laboratory Reagents
GENERAL CHEMICAL DIVISION
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40 Rector Street, New York 6, N. Y.

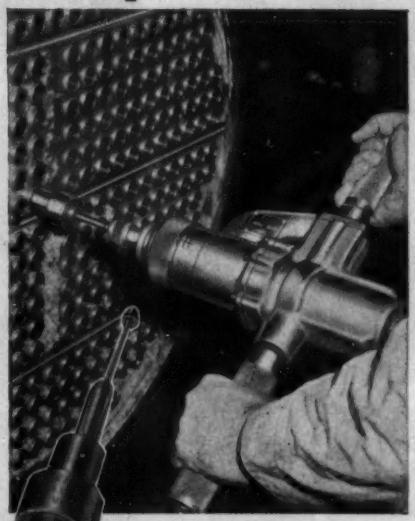
Offices: Albany* • Atlanta • Baltimore* • Birmingham* • Boston* • Bridgeport* • Buffalo* • Charlotte* • Chicago* • Cleveland* • Denver* • Detroit* • Houston* Jacksonville • Kalamazoo • Los Angeles* • Milwaukee* • Minneapolis • New York* • Philadelphia* • Pittsburgh* • Providence* • St. Louis* • San Francisco* Seattle • Kennewick* and Yakima (Wash.) In Canada: The Nichols Chemical Company, Limited • Montreal* • Toronto* • Vancouver* *Complete stocks carried here.

For more data on advertised products, use Readers' Service Cards, last page.

Roll tubes automatically to uniform accuracy!

AIRETROL is a great new advancement in automatically controlled tube rolling. It combines a powerful pneumatic motor drive and precision control into one compact, lightweight, easy-to-operate tool.

Simple adjustment sets AIRETROL to correct expansion. Torque sensing cam controls expansion automatically to .001 of an inch.



NEW

AIRETROL

TUBE EXPANSION CONTROL

EASY TO OPERATE...

QUICKLY ADJUSTED FOR ROLLING TUBES ¼" TO 1½" I. D.

AVAILABLE SPEEDS: 700, 550 AND 400 RPM

AIRETROL eliminates guesswork . . . there's no over or under expansion. Every tube joint can be rolled to maximum tightness and holding strength, assuring longer service.

FASTER ROLLING... LESS OPERATOR FATIGUE

PNEUMATICALLY OPERATED

AIRETROL's cushioned shut-off prevents sudden shock or strain on operator. Entire cycle is smooth, fast, easy. Average operator can roll up to 12 tubes per minute with AIRETROL.

Send for illustrated and descriptive Bulletin No. 64 on AIRETROL.

BRANCH OFFICES: New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge.
REPRESENTATIVES in principal cities of U.S.A., Canada, Mexico, South America, England, Puerto Rico, Italy, Japan, Hawaii.
EUROPEAN PLANT: Vlaardingen, The Netherlands.
CANADIAN PLANT: Brantford, Ont.

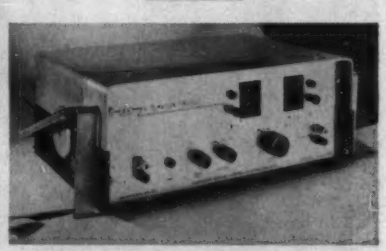
AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD, OHIO

New Equipment . . .

of a multiple installation of smaller capacity generators.

In addition to the new signal system, the Oxweld MP-11 has several other features that assure safety. Each generator is equipped with an automatic carbide and water shutoff system, a hydraulic backpressure valve, and pressure relief valves. The completely enclosed recharging cycle limits entry of air to insignificant amounts. Linde Co.

Circle E4 green card, last page



Chromatograph Readout Eliminates Calculations

The SIE Chromatograph Readout provides instantaneous, integrated, digital readout of the signal peaks produced by chromatographs currently being used throughout the process industry. The time-consuming measurement of peak areas by planimetry is eliminated. The unit is designed to accept an input signal directly from the sensing bridge in a chromatograph. This signal is amplified, accurately integrated and displayed on an impulse counter with an electrical zero reset. Two counters are provided, one for individual peak count, the other for accumulated count. The accuracy of the entire readout is equal to that of present hand integration methods. Output terminals for a recorder are provided. Transistor circuitry in place of vacuum tubes or relays provides maximum reliability. Southwestern Industrial Electronics Co.

Circle E5 green card, last page

Tubing Corrosion Is Topic of Reprint

Engineers and others associated with the design and operation of refinery equipment will be interested in a reprint of an article titled, "The Corrosion of Ferrous-Metal Tubing in Refinery Service." The article deals with separate phases of ferrous metal corrosion in the refinery field. The Tubular Products Division of the Babcock & Wilcox Co.

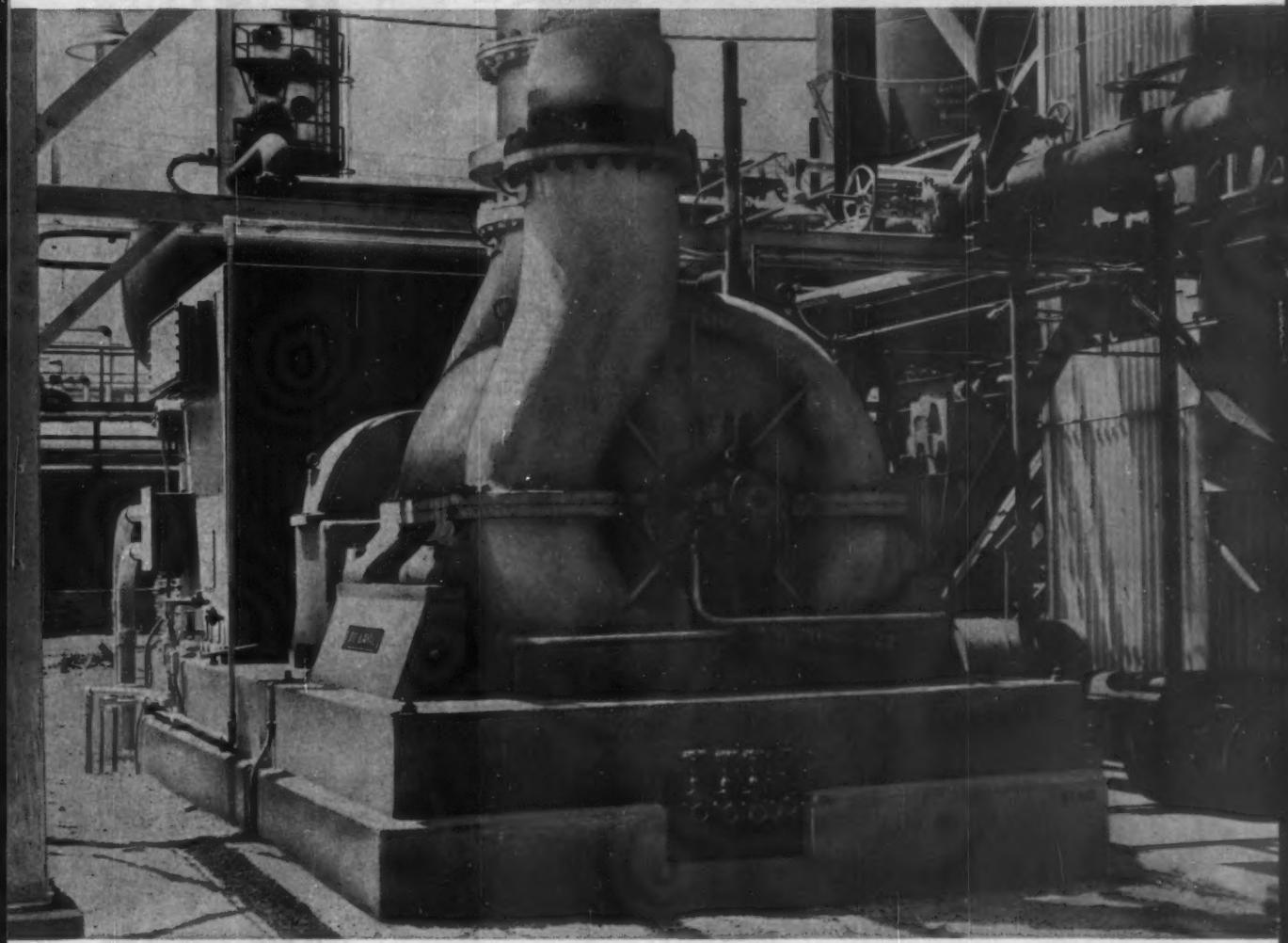
Circle E6 green card, last page

Chemicals Used For Industrial Weed Control

Weeds and brush on industrial sites, such as tank farms, can be cleared chemically at a cost averaging one-third below that of hand or mechanical cutting, according to a booklet on the subject just published.

The 24-page booklet points out that various formulations of 2,4-D and 2,4,5-T and mixtures of these chemicals now make possible year-round programs of foliage, basal and stump spraying for maximum

Another **DE LAVAL** *combustion air compressor dependably serves refinery cat cracker*



On stream at the Coffeyville, Kansas plant of the Cooperative Refinery Association, this De Laval Centrifugal Compressor delivers 24,100 cfm of air. Inlet pressure is 14.0 psia, discharge pressure 38.9 psia. Compressor output is controlled with adjustable inlet guide vanes.

This De Laval main air compressor is driven by a 2500 hp, 1800 rpm motor. Shaft speed is increased to 4800 rpm through a De Laval double helical speed increasing gear.

Cooperative Refinery Association is only one of many refiners who have specified De Laval Compressors. Whether you need to handle light or heavy gases at high or low pressures in catalytic cracking, reforming, alkylation, coking or any similar service, it pays to look to De Laval. Rugged De Laval centrifugal compressors perform dependably in heavy-duty continuous operation. De Laval has more than 40 years of experience in solving gas compression problems.

DE LAVAL *Centrifugal Compressors*

DE LAVAL STEAM TURBINE COMPANY
811 Nottingham Way, Trenton 2, New Jersey

DL-303

New Equipment . . .

weed and brush control at substantial long-term savings of time and money.

Properly carried out, such spray programs are highly effective in reducing weed and brush population so that control becomes easier and more economical each year.

A feature of the new booklet is a chart which lists more than 50 common woody plants controllable with 2,4-D, 2,4,5-T and combinations of these chemicals and the recommended rates of foliage spray for each. Monsanto Chemical Co.

Circle E7 green card, last page

Titanium Immune To Corrosive Conditions

Engineers and others responsible for the design and operation of processing equipment will be interested in the reprint of an article titled, "Present Status and Future Potential for Titanium Tubing." This 8-page article describes the involved method of producing titanium tubing and outlines briefly its many characteristics. The article explains why titanium tubing is uniquely immune to many corrosive conditions which have long been the "number one problem" of process engineers. Babcock & Wilcox Co.

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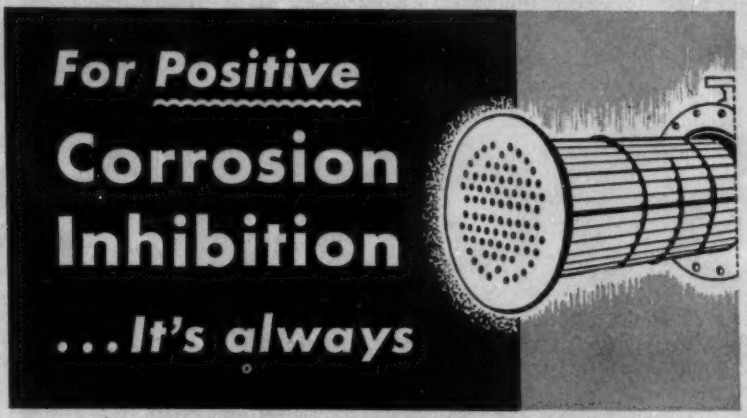

WRIGHT PENECHROMES

(Zinc Chromate Organics)

- ✓ Proved in Cooling Systems for over 11 years
- ✓ Safe pH Ranges*
- ✓ No Sludge Precipitate
- ✓ High Temperature Tolerance

**Cooling Tower Institute Bulletin WMS-104 Wood Maintenance for Water-Cooling Towers*

Through many years of experience Wright Engineering has developed Wright Penechromes as an effective answer to corrosion . . . if you have a common or "special" problem, write for an engineering survey of your water using equipment. A comprehensive conditioning program by Wright will pay big dividends.

Write us on your company letterhead for the new Wright Cooling Water Calculator—it quickly calculates operational data.

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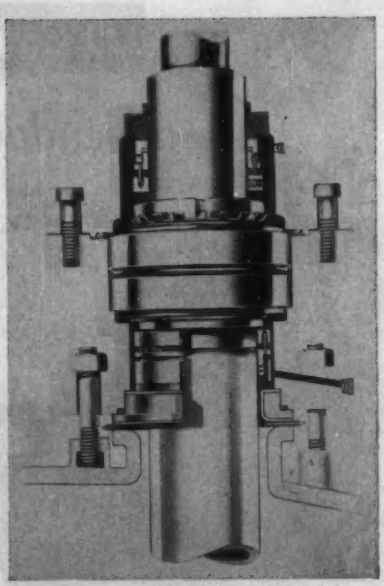
- Softeners, Filters and other external Treating Equipment
- Nelson Chemical Proportioning Pumps

Wright CHEMICALS

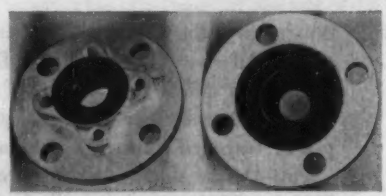


Mechanical Seals Protect Glass Lined Vessels

No more leakage under pressure, that's the miracle news about the exclusive rotary mechanical seal which Glascote Products, Inc., Cleveland, subsidiary of A. O. Smith Corp., is using on all glass lined pressure vessels they produce for the chemical industries. The non-contamination seal has proven itself in action, with manufacturers who are operating glass lined vessels under toxic or explosive conditions.

The rotary mechanical seal has a balanced pressure system available to provide the absolute protection needed for all materials being processed inside a pressure vessel. Its Timkin bearing assures constant alignment preventing agitator wobble. Sealing materials include a carbon gland insert and insoluble teflon for the seal rings. Glass coating protected by these seals assures contamination free operations. The seal is featured in a new 330 psig spherical reactor, just introduced. The company produces complete systems of glass lined equipment; reactors, receivers, condensers, evaporators, storage tanks and complete pipe and fitting—all protected with acid-alkali resistant glass coating. Glascote Products, Inc.

Circle E9 green card, last page



Corrosion Proof Reducing Flanges Teflon Lined

Tapered reducing flanges have just been added to a line of pipe and components which make up a complete corrosion proof system.

Fluoroflex-T reducers have a unique combination of properties which provide uninterrupted service life resulting in unmatched operating economy. As with the

Flexitallic® — Industry's Spiral-Wound Seal Since 1912

NOW IDENTIFIED FOR ENGINEERS

Flexitallic Blue is a positive means of gasket identification.

The blue dye in the Canadian asbestos filler tells an engineer that this is a genuine Flexitallic Spiral-Wound Gasket, made to just one standard of quality since 1912.

Flexitallic Gaskets are exclusively spiral-wound. Constructed to meet specific conditions of thermal and mechanical shock, vibration, weaving and other joint stresses.

The high safety factor of Flexitallic Gaskets results from two unique characteristics — compression response of the gasket is directly related to bolting for each application; exacting mechanical controls assure that manufactured gaskets conform to specification.

Whenever you are confining fluids in a critical pressure/temperature range, insist on Flexitallic Spiral-Wound Gaskets. Look for Flexitallic Blue.

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Flexitallic®
SPIRAL-WOUND GASKETS

FOR PIPE FLANGES, PRESSURE VESSELS AND PROCESS EQUIPMENT

* Flexitallic is a registered trade name. No one else can make a Flexitallic Gasket. Look for *Flexitallic Blue* — it's our exclusive blue-dyed Canadian asbestos filler.

...top utility at lowest cost

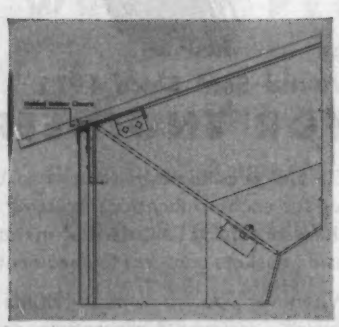
Here's ideal, low-cost, top-utility housing for oil field pump stations and compressor stations, refinery, bulk station operations. It's the new Truscon all steel "Budget Building."

Basic framework is of rigid frame design, shop fabricated from hot rolled structural sections, complete with connection plates and anchor bolts. Purlins and girts are cold formed channel sections.

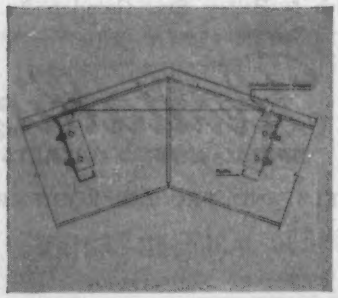
Roofing and siding are 26-gage galvanized roll formed ribbed sheets, 24-inches wide and in continuous lengths. Sheets are rolled from Republic tight-coated, continuous hot dip galvanized steel . . . will not flake, peel or crack. No painting needed.

Truscon "Budget Buildings" are available for immediate delivery in widths of 32, 36, 40, 44 and 48 feet—12- and 14-foot heights, in any length necessary. Orders are filled fast from "off-the-shelf" stocks of pre-engineered materials. Roofing, siding, windows, doors and hardware are shipped to the job site as a package.

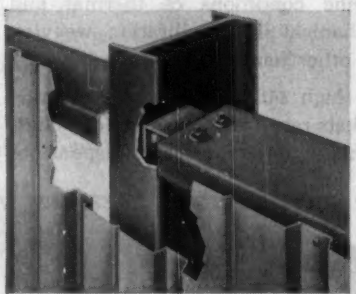
Learn more about Truscon "Budget Buildings". Send for full color brochure.



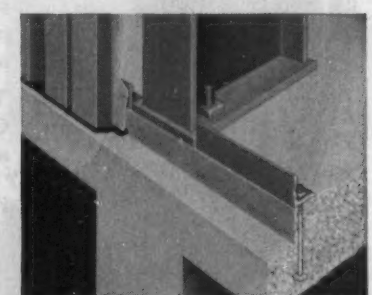
Section through eave showing molded rubber closure between siding sheet and roofing sheet. Also shown are eave strut and bracing connection to rigid frame.



Section through ridge showing molded rubber closure between rigid cap and roof sheet. Also purlin connection to rigid frame. Connections make building weathertight.



Section through sidewall at girt showing girt connection to rigid frame and fastening of sidewall to girt. Strong, sturdy building can be erected fast at the job site.



Section through sidewall at sill showing curb angle, rigid frame anchorage and siding detail. All connection plates, connection bolts and anchor bolts furnished complete.

For more data on advertised products, use Readers' Service Cards, last page.

REPUBLIC ALLOY STEELS provide the oil field equipment builder a wide variety of analyses to produce lighter, more efficient designs with no sacrifice of strength or safety. Hardness resists abrasion; toughness and ductility resist impact and heavy loads. Ideal for bits, tongs, elevators, blocks, chain, sucker rods, draw work components. For more information, send coupon.

REPUBLIC'S COMPLETE LINE OF PIPE PRODUCTS range from continuous butt weld, shown above, to big diameter fusion weld line pipe. For data on sizes and types, mail coupon.

REPUBLIC ELECTRUNITE® GROOVED-END TUBING goes hand-in hand to serve your temporary, semi-permanent and permanent piping system needs. The combination of Republic ELECTRUNITE Light Weight Grooved-End Tubing and Victaulic "Vic-Easy" method of coupling saves installation time and reduces operating costs. Write today for attractive, illustrated brochure.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
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Please send the following information as soon as possible:

☐ Truscon "Budget Buildings" ☐ Republic Alloy Steels
☐ Oil Country Pipe Products ☐ Grooved Tubing Brochure

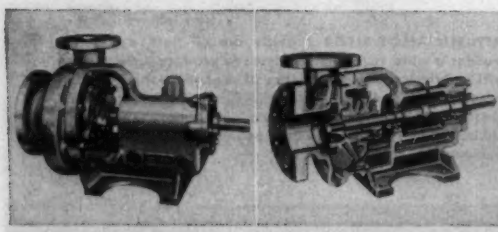
Name_____ Title_____

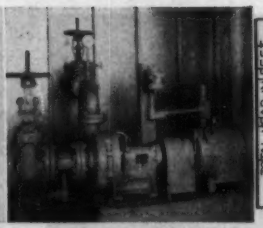
Firm_____

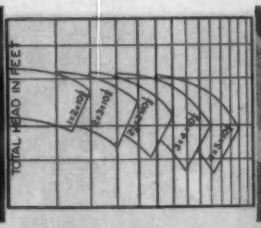
Address_____

City_____ Zone____ State_____

For more data on advertised products, use Readers' Service Cards, last page.







BECAUSE...

PEERLESS CHEMICAL PUMPS:

MEET critical standards of construction, you benefit from longer pump life, less maintenance, and sharply reduced incidence of system shut down caused by pump failure. Top quality Peerless construction means a dependable, rugged pumping unit you can count on to stay on the job for years longer.

PROVIDE proved operating history, you benefit from the knowledge that you're not buying a pump in the dark. Analysis by Peerless of customer pump operating records allows continuous product improvement. Correlation of this data provides Peerless with answers to nearly all field pumping problems.

OFFER optimum performance range, you benefit from the economical performance only the exact pump for the job can give you. The Peerless process pump line of over 78 models, sizes and frames, plus thousands of combinations, assures you of pinpoint pump selection that effects direct savings in cost.

EMBODY benefits of research in all areas of design, construction, and application. Typical of the many considerations in the design and manufacture of a Peerless pump is the ascertaining of effects of radial loads. **An interesting 8 page booklet discussing this phase of pump design is available to you upon request.**

Engineers and Pump buyers say:

NOW WE CAN BE SURE!

...buy and apply PEERLESS PUMPS

Putting Ideas to Work

fmc FOOD MACHINERY AND CHEMICAL CORPORATION

Peerless Pump Division

Plants: LOS ANGELES 31, CALIFORNIA and INDIANAPOLIS 8, INDIANA

Offices: New York; Atlanta; St. Louis; Phoenix; San Francisco; Chicago; Fresno; Los Angeles; Plainview and Lubbock, Texas; Albuquerque.

Distributors in Principal Cities. Consult your telephone directory.

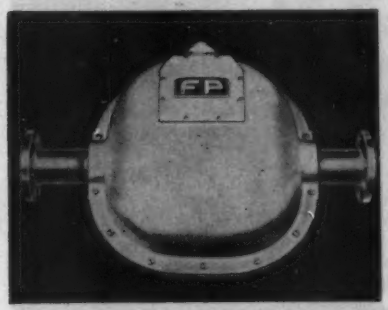
For more data on advertised products, use Readers' Service Cards, last page.

company's Type S pipe, the reducing flanges are lined with Fluoroflex-T, a virgin Teflon compound. The full face of the flange, with its asbestos backing, is an integral part of the liner providing the ultimate in corrosion protection and chemical inertness. Separate gaskets are no longer required. Material being conveyed cannot contact metal anywhere in the reducing flange assembly. Contamination by corrosion products is, therefore, prevented also.

Thermal shock, which so often damages reducers lined with fragile coatings, has absolutely no effect on the reducers. Forming process compensates for the thermal expansion and contraction differential between the liner and housing, and the liner itself is semi-flexible.

The flow passage is tapered in design to minimize turbulence. The reducers withstand 150 psi pressure and full vacuum at temperatures ranging from —100 F up to +500 F. The flanges have standard 125 pound or 150 pound ASA bolt circles. They are available in sizes ranging from six inches to 1 inch ASA pipe sizes. Reduction ratios are generally in one size steps. Resistoflex Corp.

Circle E10 green card, last page



Acids and Slurries Give No Troubles To Flowmeter

A new magnetic flowmeter accurately measures the flow rate of "difficult" liquids such as acids and slurries without adverse effects to the meter. Major features are: manual adjustment for setting any desired flow rate at full scale. (The one inch meter can be set to handle from 3 to 40 gpm at full scale; the one-half inch meter as low as one gpm.); unrestricted flow; readings unaffected by velocity profile, density, or viscosity; voltage changes between 90 and 125 volts and frequency changes between 55 and 65 cycles have no effect on readings; special piping for long metering runs is not required; flow can be measured in either direction. Fischer & Porter Co.

Circle E11 green card, last page

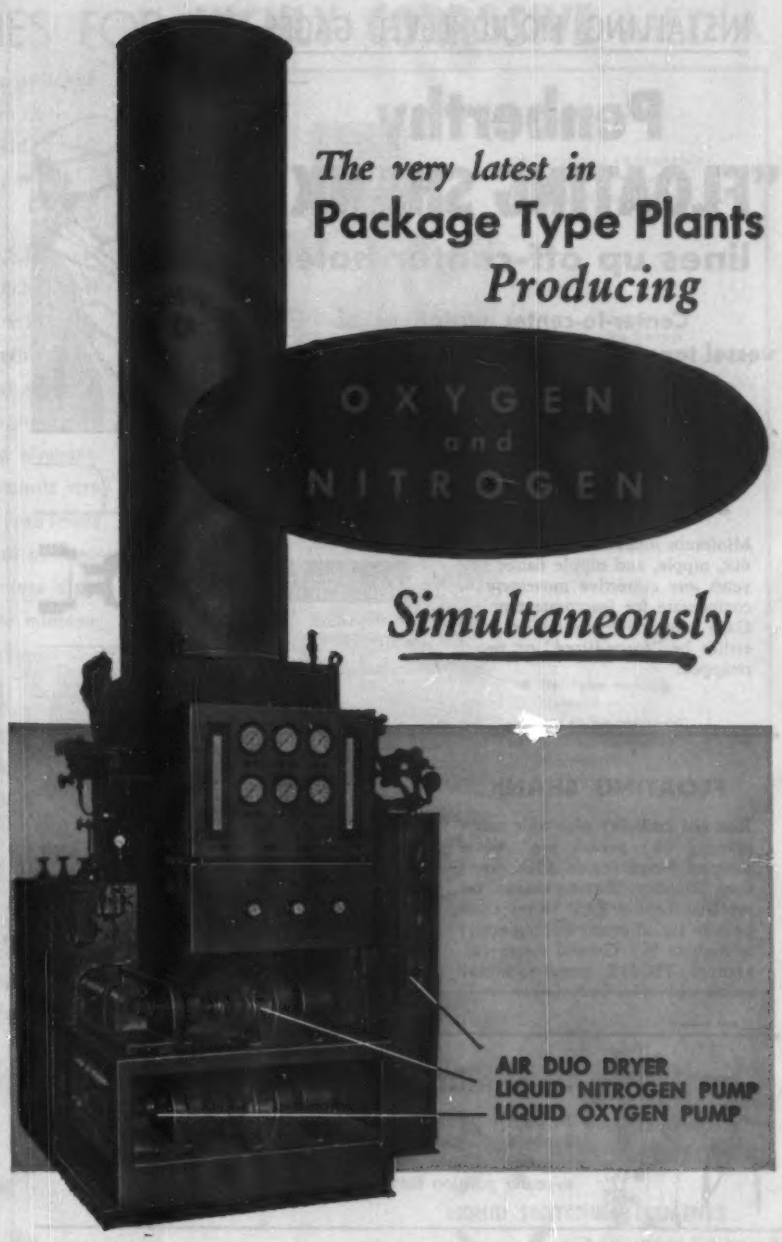
Reforming Compressors Described In Bulletin

Just published is a new bulletin on the company's centrifugal compressors designed for catalytic reforming.

These compressors efficiently handle a wide volume range of low density hydrocarbons used in the refining process. They recycle the gases at relatively high pressures and are built in a complete range of sizes, according to the needs of individual installations.

The units are built with either vertically

The very latest in
Package Type Plants
Producing
OXYGEN and NITROGEN
Simultaneously



With the introduction of our latest, improved design Package Type Generating Plants, production of high purity Oxygen and Nitrogen simultaneously *increases* production 60% over the production of Oxygen alone, *plus* a corresponding reduction in the *cost* of manufacture. Due to its compact design, a minimum of floor space is required and streamlined panel assembly insures instant visibility of all control gauges. Stock sizes from 1500 to 10,000 cu. ft. per hour. Larger and smaller sizes available. 99.99% Argon available on large size plants.

We invite your inquiry.

INDEPENDENT ENGINEERING COMPANY, Inc.
Manufacturers of
CONSULTING IECO DESIGNING
CYLINDERS AND GAS PRODUCING EQUIPMENT
ACETYLENE - OXYGEN - NITROGEN - ARGON

For more data on advertised products, use Readers' Service Cards, last page.

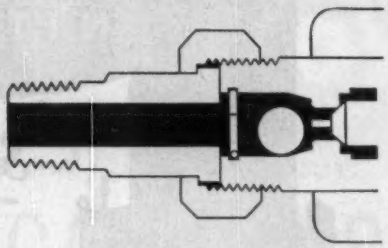
INSTALLING LIQUID LEVEL GAGES

Penberthy "FLOATING SHANK" lines up off-center holes

Center-to-center variations of vessel tappings or gage assembly can cause costly, inaccurate mounting.

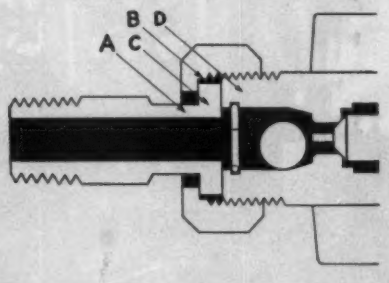
STANDARD SHANK

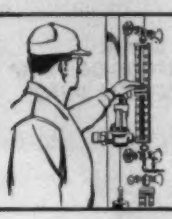
Minimum tolerance between union nut, nipple, and nipple flange prevents *any* corrective movement to compensate for inaccurate tapping. Gage and valve assemblies must either be "force-fitted" or vessel retapped.



FLOATING SHANK

Recessed neck (a) plus wide union opening (b) permit 5/16" movement of flange (c) in ANY direction. Together, "floating shanks" on top and bottom gage valves compensate for off-center tapping errors as high as 3/8". Ground flange (c) assures TIGHT metal-to-metal union with valve body (d).





...eliminates mounting strains

By permitting freedom of movement up to 3/8" in ANY direction, Penberthy "floating shank" principle protects against mounting stresses . . . allows gage and valve assemblies to seek TRUE center-to-center position between inaccurately tapped holes.

AN EXCLUSIVE EXTRA AT NO EXTRA COST

- cuts installation time and replacement costs by 50%
- provides true gage and valve alignment on incorrectly tapped vessels
- eliminates "force-fitting" and subsequent strains on gage and valve assemblies
- prevents possible damage to entire installation
- reduces unnecessary glass breakage due to gage distortion

WRITE for Catalog 36 showing complete line of liquid level gages and valves, Standard or special assemblies available through local suppliers or direct.

PENBERTHY MANUFACTURING COMPANY *Division of Buffalo-Eclipse Corporation*
Dept. R 1242 Holden Avenue Detroit 2, Michigan

Everywhere... you're seeing more **PRODUCTS BY** PENBERTHY

EJECTORS
INJECTORS
CYCLING JET PUMPS
LIQUID LEVEL GAGES
GAGE VALVES
SUMP PUMPS

New Equipment . . .

or horizontally-split casings. The vertically-split casings can have either top or bottom intake and discharge, while the horizontally-split casings have both connections conveniently located on the bottom casing half.

Special shaft seals are available, and the driver can be a steam turbine, combustion gas turbine or motor-gear combination. Ingersoll-Rand.

Circle E12 green card, last page

Bulletin Describes Standard Tank Fittings

An eight-page data bulletin on Tank Fittings and Accessories is now available. This is an illustrated catalog-type presentation of their line of standard tank fittings and accessories including foot valves, flat flanges, screened air vents, quick opening tank plugs, thief hatches, emergency valves, etc. Modern Welding Co.

Circle E13 green card, last page

Digitizer To Widen The Use of Mass Spectrometry

A new all-electronic digitizer is expected to materially widen the use of mass spectrometry by cutting the present time-consuming process of measuring and tabulating peak heights from the mass spectrometer's oscillogram.

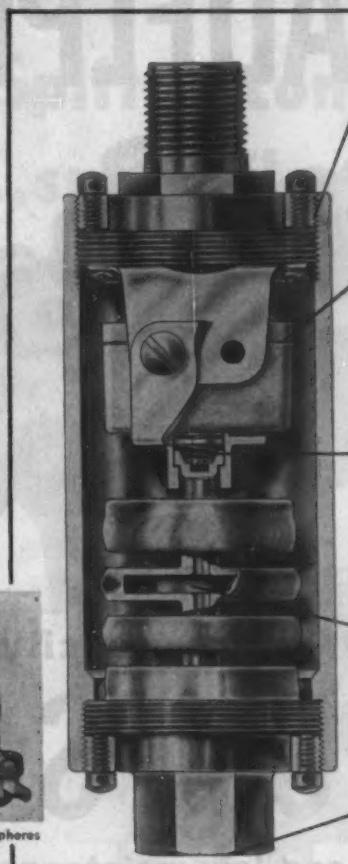
It is a completely unprogrammed digitizer designed to provide tabulated digital conversion of the analog output from CEC's Type 21-103C Mass Spectrometer. It converts the amplitude and true mass number of each mass-spectrum peak (except metastable peaks) into a signal to a parallel-entry type paper-tape printer. A special printer is available for printing and simultaneously actuating an IBM card punch, or paper tape punch.

Operating at the speed of a normally scanning mass spectrometer, the Mascot eliminates the time necessary to manually identify and measure peaks on an oscillo-

PRESSURE SWITCHES FOR **HIGHLY CORROSIVE** MEDIA

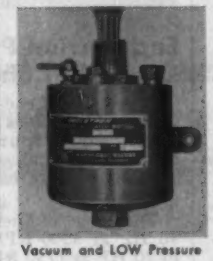
This new tier-tube line of Meletron pressure switches is available in materials suitable for use with concentrated hydrogen peroxide, fuming nitric acid, liquid oxygen, proprietary amine fuels, fluorine, mixtures of fluorine and liquid oxygen and others.

Proof pressures range from 224 to 6000 P.S.I., pressure settings from 2 to 4800 P.S.I. Switches will operate in temperatures from −65° to +275° F. Standard pressure port fitting is ¼" internal pipe thread but may be substituted by special welding fitting. The housing serves as a pressure tight safety capsule in case of a break in the sensing element. Single pole double throw switching elements are rated to 10 amps., for AC and DC circuits. Free leads or Cannon plug are optional for electrical connection. As an added safeguard, the stainless steel models will withstand 2000° heat for five minutes.



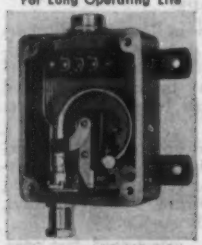
- Threaded (adjustable) Construction shown; Welded construction optional
- Snap action Switch
- Overtravel protection
- Tier-tube sensing element — not to be confused with an accordion diaphragm.
- ¼" internal pipe thread pressure connector is standard — Welding fitting optional.

For Long Operating Life



Vacuum and LOW Pressure

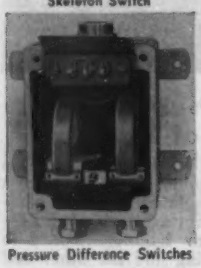
For Explosive Atmospheres



Pressures to 12,000 P.S.I.

A complete line of several hundred standard models, off-the-shelf items, includes everything from vacuum to 20,000 P.S.I. proof pressure.

Skeleton Switch



Pressure Difference Switches

All have these features built in:

ACCURACY and DEPENDABILITY
maintained during operating life due to direct acting design.

We don't use

LINKAGES and BEARINGS
which as they wear, make the setting of the pressure switch drift.

OPERATION IN ANY POSITION
which saves the installation costs encountered in mounting a switch that uses liquid switching elements.

We don't use

LIQUID SWITCHING ELEMENTS
which make the switch difficult to mount and very critical to vibration.

IMMUNITY TO VIBRATION
you can mount the switch directly on your vibrating or moving equipment.

We don't use

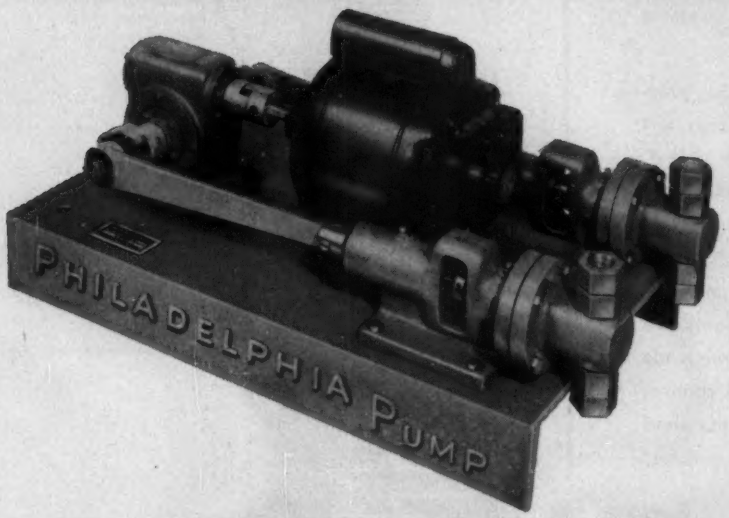
ACCORDION DIAPHRAGMS
which make the pressure switch sensitive to vibration.

BARKSDALE VALVES

PRESSURE SWITCH DIVISION

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

PHILADELPHIA



controlled capacity

PUMPS

Accuracy and low maintenance to meet fluid proportioning requirements in Chemical Processing, Refining and Boiler Feed Applications.

Philadelphia proportioning pumps feed precisely metered fluids or slurries into low or high pressure systems in nearly any desired ratio with flow, temperature, pressure, conductivity, PH and other controlled process variables. Control may be manual or automatic—with electric, hydraulic or pneumatic systems.

Models may be obtained to handle a great variety of "tough," corrosive and viscous materials. *Write for full information.*

PHILADELPHIA PUMP

Division of American Meter Co.

13500 Philmont Avenue, Philadelphia 16, Pennsylvania

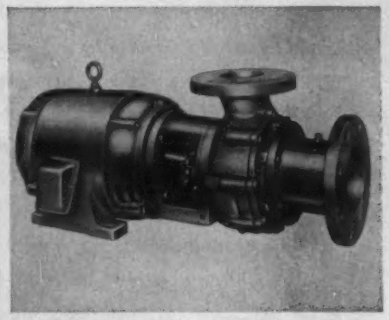
High-Pressure Pumps • Controlled Capacity Pumps • Chemical Feed Systems

New Equipment . . .

graph record. In addition, its digital record removes any possibility of human error in record "picking." Readout from the Mascot is continuously available during the mass spectrometer's run, for on-the-spot analysis or dispatching to a computer.

A prototype unit is reportedly saving the user one and one-half man-days per day over the manual method. Consolidated Electrodynamics Corp.

Circle E14 green card, last page



End Suction Pump Has Low NPSH Characteristics

A new line of end-suction-type, BC, general purpose pumps in close-coupled, horizontal, flange-mounted vertical, base-mounted vertical and pedestal-mounted horizontal design has recently been introduced.

The range of sizes in one-fourth HP to 40 HP at 3500 RPM and one-fourth HP to 20 HP at 1750 RPM.

These pumps possess low NPSH characteristics to meet critical suction conditions. They have standard approved motors and the pumps may be readily changed from packing to seals by means of interchangeable inserts.

The pumps have steep sloping characteristics with constantly rising head to shut-off, and low impeller velocities for smooth, quiet operation. Aurora Pump Division, The New York Air Brake Co.

Circle E15 green card, last page

Flexible Shaft Allows Observation of Pipe Cut

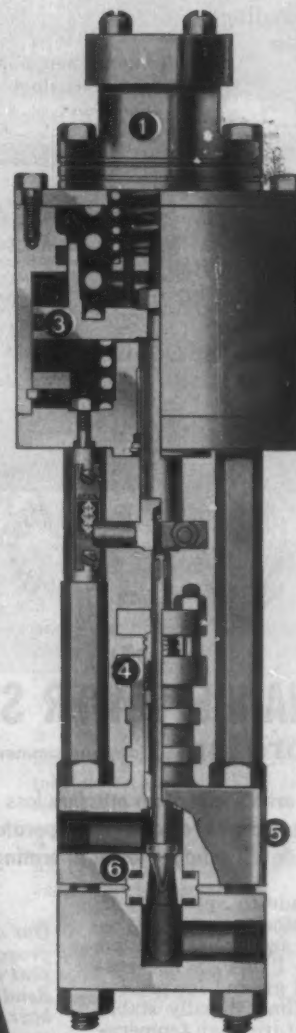
A flexible shaft has been designed to allow complete visibility of the company's pipe cutting or beveling machine operations. It is made from a length of flexible tubing, with a crank handle attached to one end of the tubing and the other end

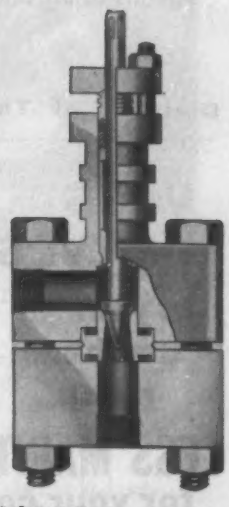
For more data on advertised products, use Readers' Service Cards, last page.

Split second action ...small flow control ...at 6,000 psi

New achievement by Annin in high pressure control and precise valve response for Research–Development–Process applications

Annin's new Model 9460, designed for working pressures to 6,000 psi, provides research, pilot plant and process control engineers with an extremely responsive small flow control valve suitable for low capacity systems. The operator will fully stroke in either direction in 0.75 seconds or less. New design features include: ❶ integral positioner, open-on-air-failure or close-on-air-failure action; ❷ Annin's 600 Series Domotor operator; ❸ differential area piston, eliminating need for loading regulator; ❹ universal stuffing box for –400°F to 750°F; ❺ offset globe or angle body design; ❻ valve plug stem and seat ring common to both globe and angle bodies. For reliable fluid control and flexibility of application Annin offers the *best source* for solving any small flow control problem.





Model 9461 *angle body*

Angle bodies are available with body sections rotatable in 90° increments for piping convenience.

YOURS FOR THE ASKING—
Complete information and specifications are contained in Bulletin No. 9400. Write for your copy today.

ANNIN *Control* **VALVES**

THE ANNIN COMPANY
DIVISION OF THE ANNIN CORPORATION
6570 Telegraph Road, Los Angeles 22, California

For more data on advertised products, use Readers' Service Cards, last page.

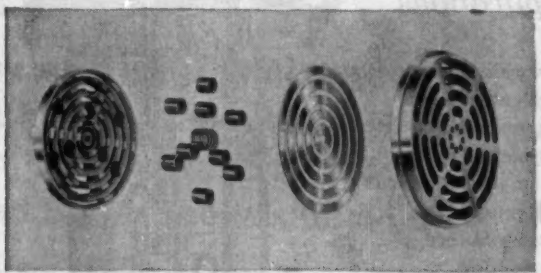
BY-PRODUCTS...

will PURCHASE or REFINE . . . for your account.

The facilities and experience of Truland may be employed advantageously for the economical upgrading and disposal of solvent mixtures and organic by-products. Our technically trained personnel are available to discuss the refining of any solvent mixture or organic by-products.

Division of The Trubek Laboratories Incorporated

VOSS VALVES in your machine mean



LESS MAINTENANCE, FEWER SHUTDOWNS for your compressor. (air, gas, ammonia)

- up to 40% more valve area • minimum pressure loss • higher efficiency
- less power consumption • normal discharge temperature
- quiet, vibration-free • utmost safety • lower operating costs

VOSS VALVES are made to specification, machined from solid stock (not cast) — VALVES and PLATES are of heat-treated alloy or stainless steel; PLATES are machined, not stamped, and ground for precise close-tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. SPRINGS, of heavy rectangular sections and large diameters, add to dependability and safety.

Our detailed proposal will be sent without obligation. Send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street, New York 54, N. Y.

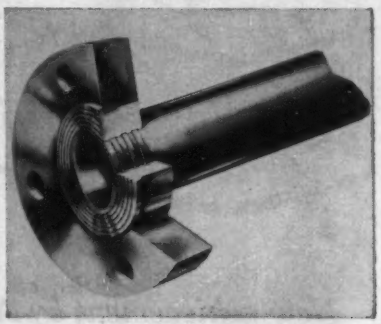
New Equipment . . .

attached to the crank pinion on the machine. As the operator turns the crank, the ring gear is put in motion, and the torch begins its revolution around the pipe.

This attachment is especially useful when cuts or bevels are being made on the larger sized pipe, where the operator has difficulty watching the cut from his normal position.

With the flexible shaft, the operator can stand in any position and observe the cut through the full circumference of the pipe. H & M Pipe Beveling Machine Co.

Circle E16 green card, last page



No Welding Required Using Flange With Insert

A new stainless steel serrated insert with carbon steel flange has been announced. Designed specifically for use with lightwall stainless steel piping systems, where possible future changes make welding of joints undesirable, the connection can be flanged.

Tight joints are assured because the pipe is expanded directly into the insert flange to make leak-proof connections. A serrated insert holds the pipe to eliminate rotation of the pipe in the joint. The flange is held to the insert by a lip that allows the flange to be pulled up tightly against the Neoprene or Teflon gaskets.

Speedline fittings are available in a range of sizes and types to provide a complete system for connecting lightwall stainless piping without welding. Such systems are readily connected with existing conventional systems. Speedline Division, Horace T. Potts Co.

Circle E17 green cart, last page

Nitrile Rubber Now Made To Resist Ozone Cracking

Development of the first nitrile rubber to resist ozone cracking has been announced.

According to the company, compounds of Hycar 1072 nitrile rubber can be made which are unaffected by ozone during an extended test period, even when the compounds are soaked in hot oil before exposure to ozone.

This quality, combined with superior oil resistance, good flexibility, high strength and exceptional resistance to abrasion and oxidation, suggests several important applications. These include electrical insulation, especially near ozone-producing spark discharges, and fabric coatings for both indoor and outdoor uses.

Rubber parts which are under extension stress during use are more likely to be

18,000 leading shops depend on Kroil when a frozen bearing, bushing or bolt threatens production or starts to cost expensive man hours.

During seventeen years they have learned that it pays to use Kroil first and save parts. In these days of high labor costs, shops cannot afford to use hammer-and-chisel methods when stuck-together parts cause trouble.

WHAT USERS SAY:

"As I remember, we had quite a bit of construction machinery lying around in our yard. Suddenly there was a rush call for some of it but 90% of the pulleys on this machinery was locked by rust. We then applied Kroil to each one and the next morning the machinery was ready to roll."

Try Kroil at our risk. Send for a gallon—use it under the worst conditions. Return it for full credit if not satisfied. Kroil, $4.00 a gallon; Kroiler, $1.50 each . . . together, $4.95, f.o.b. Nashville.

KANO LABORATORIES
1094 THOMPSON LANE
NASHVILLE 11, TENN.

VIKING ROTARY PUMPS

• Cut-Away View Showing Viking's Gear-Within-A-Gear Principle

The unique and unusually simple construction of Viking Pumps . . . with only two moving parts . . . assures you of long, easy-maintenance operation with all grit-free liquids.

Let Southern Engine & Pump Company show you how Viking Pumps can solve your pumping problems. We invite your inquiries.

Distributors

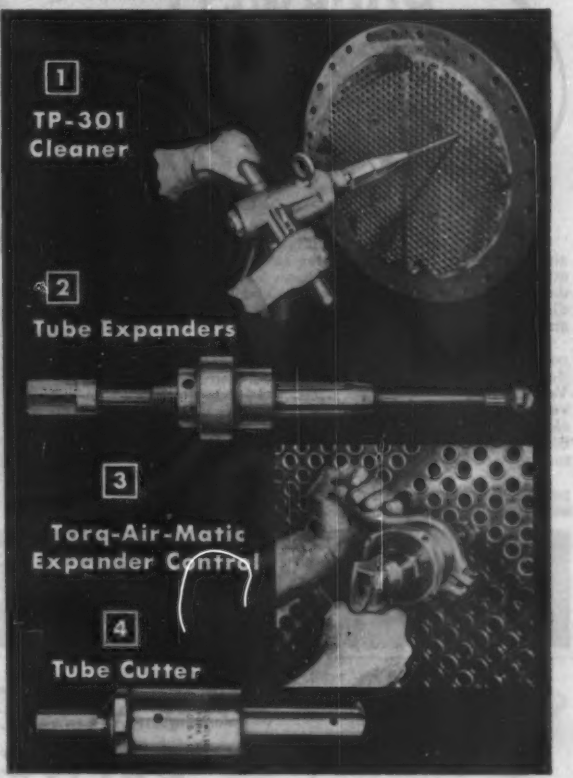
SOUTHERN ENGINE & PUMP COMPANY

MANUFACTURERS • MACHINERY FACTORS • CONTRACTORS

Service Facilities at: Houston–Dallas–Kilgore–San Antonio–Edinburg Corpus Christi and Beaumont, Texas

Keep Heat Exchangers on stream with

WILSON TUBE MAINTENANCE TOOLS



1 Heavy-duty TP-301 Cleaner is a positive air-driven, hollow rotary shaft, drill type tool. Tube is scavenged with air or water while cleaning.

2 Wilson Models 41 and 44 Tube Expanders incorporate an improved, adjustable ball bearing thrust collar and are designed for efficient, easy rolling and maximum roll length adjustment for various tube sheet thicknesses.

3 New Wilson Torq-Air-Matic is the first and only air-driven tube expander drive that accurately controls tube expansion by directly measuring torque output at the mandrel.

4 Wilson tube cutter is easy to use and does a fast job. Cutter sizes and shanks available to meet all heat exchanger requirements.

Write today for your copies of Wilson Tube Cleaner catalog No. 77 and Wilson Tube Expander catalog No. 88. TW-681

Representatives in principal cities
THOMAS C. WILSON, INC.
21-11 44th Ave., Long Island City 1, N. Y.
Cable address: "Tubeclean", New York

WILSON
TUBE CLEANERS • TUBE EXPANDERS

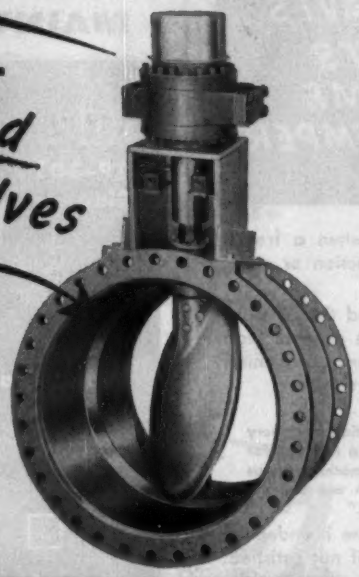
PROBLEM: TIGHT Shut-off of HOT Gases

SOLUTION:

ROCKWELL

Stress Sealed

Butterfly Valves



Controlling and shutting off the flow of hot air or highly corrosive, abrasive or dirty gases at high pressures and temperatures to 1350°F. demands precise closure between valve body and disc under ambient conditions. Machine tolerances are not enough.

Dimensional changes under such punishing conditions are compensated for by the unique design of the Rockwell Stress Sealed Butterfly Valve. The alloy stress seal band, welded in the valve body, is inflated when the disc reaches the closed position. It deflates upon opening the disc, permitting "free wheeling" with minimum torque load.

The valve can be used for pressures to 600 psig. Made in all sizes to 144", furnished with any type of mechanical operator. Write for details.

W. S. ROCKWELL COMPANY

2368 ELIOT STREET • FAIRFIELD, CONN.

Sales Representatives in Principal Cities

Quoth Sir Galvaknight: Only Complete PROTECTION is Good Enough

And the best *complete* anti-rust protection for iron and steel is hot-dip galvanizing. The hot-dip process seals out corrosion on *all* surfaces, as no other protective coating can. Armor-plate your iron and steel with hot-dip galvanizing by the Southwest's largest commercial galvanizers, the Nowery J. Smith Company!

Nowery J. Smith COMPANY

Commercial Galvanizing

one of the SMITH

8000 Hempstead Hwy. UNdrwd 9-1425

P. O. Box 7398 Houston 8, Texas

New Equipment . . .

attacked by atmospheric ozone than are those which are not under stress. It should do well in finished parts which are likely to be under tension for long periods.

A Hycar 1072 compound, after immersion in ASTM No. 1 oil for 70 hours at 212 F, showed excellent resistance to ozone exposure. The compound containing an added anti-ozonant showed excellent resistance to ozone both before and after immersion in hot oil. B. F. Goodrich Chemical Co.

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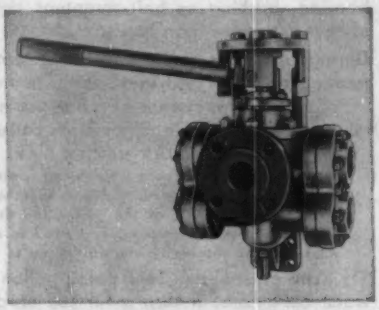

Transfer Valve Gives Fast, Smooth Operation

A new transfer valve for duplexing two strainers, heat exchangers or other equipment, where fast and smooth transfer of flow from one unit to another is required, has been developed.

Known as the Cash Standard Type 45, the valve has six ports, including a common inlet and outlet. Flow is through the single inlet, to either of two pieces of equipment, and out the common discharged connection.

Special design of the valve provides transition of flow from one unit to the other on a proportional basis, assuring a continuous flow during transfer.

A unique, single operating handle jacks-up the plug before rotation so that transfer can be made effortlessly. The plug cannot be rotated until it is clear of the seat, and an indicator shows position of the plug at all times. The handle also features an adjustable caming device to properly seat the plug.

The valve is available in two sizes: one-inch 600 pound flanged, and 1½-inch 150 pound flanged, with other sizes available upon application. A. W. Cash Co.

Circle E19 green card, last page

Ductile Iron Steam Trap Half Price Of Cast Steel

A new line of ductile iron steam traps costing less than half as much as comparable cast steel traps has just been announced. Known as the 540 Series Hydro-Flex Traps, this line is designed for service to 500 psi and 650 F, making it especially adaptable for use on process equipment in chemical plants and refineries where cast steel is normally required.

Ductile (nodular) iron, a recent metallurgical development will bend or twist without breaking under fire or explosion. Its strength, toughness and wear resistance is said to be comparable to steel. Ductile iron can be welded or brazed. ASME has

ALUNDUM* High-Purity Fused Alumina

...has many important advantages that may benefit your own operations

ALUNDUM fused alpha alumina, one of many electrochemically refined materials produced by Norton Company, is gaining increased preference for many industrial uses.

It is available in a number of forms. Of these, 38 ALUNDUM grain has proved particularly successful in applications demanding high purity. Electrically fused from Bayer-processed alumina, this white grain is 99.49% pure Al_2O_3. It is insoluble in common solvents, extremely resistant to reduction and is an amphoteric refractory with high dielectric strength. Other characteristics include:

Melting point	about 3600°F.
Specific gravity	3.94
Crystal structure	hexagonal system (rhombohedral division)
Hardness	9.0 Mohs' scale
Index of refraction	1.76 mean

Norton Also Electrochemically Refines

CRYSTOLON* silicon carbide, MAGNORITE* magnesium oxide, NORBIDE* boron carbide, FUSED ZIRCONIA and many others, including a number still under development. Having varied applications in many fields, these high-melting materials are also basic ingredients of the famous Norton Refractory Rx's — refractories *engineered and prescribed* for the widest range of uses.

For Your Own Requirements

Norton Company not only supplies these materials in crude form but is ready to work with you in processing or fabricating them to your own particular requirements. The new booklet, *Norton Refractory Grain — Electrochemically Refined,* brings you detailed information. Write for your copy to NORTON COMPANY, Refractories Division, 461 New Bond Street, Worcester 6, Massachusetts.

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

Thanks to the inherent hardness, chemical stability and high density of Norton high-purity fused alumina, engineers in various fields are finding it widely useful. For example:

For Catalytic Reactions

Norton fused alpha alumina carriers are outstanding for chemical stability and resistance to abrasion and erosion. Available in the form of spheres, rings and pellets they are used in fixed bed oxidation reactions where the application requires a low surface area (less than $1 m^2/gm$) carrier. Inert, dense ALUNDUM spheres are also available for space filler applications. Other types of ALUNDUM catalyst carriers having surface areas in the range 5–60 m^2/gm are also available.

In Thermal Cracking Reactors

Particularly in Wulff Process Generators for cracking light hydrocarbons to produce acetylene gas and Koppers-Hasche Generators for cracking light hydrocarbons to produce a variety of gases and petrochemicals — checkers made of Norton ALUNDUM high-purity fused alumina provide definite advantages. Their excellent heat transfer properties, high refractoriness and resistance to erosion caused by hot gases are important. Their ability to withstand the thermal stresses of intermittent operation assures long life. And their purity prevents side reactions with the reacting gases, thus safeguarding product quality.

In Pebble Heaters

ALUNDUM heat exchange pebbles are giving excellent results in pebble heaters for heating gases above operating temperatures permissible in conventional tube furnaces. Their great resistance to abrasion, impact and repeated heating and cooling make them the ideal heat transfer medium in these devices. Also, their high refractoriness prevents them from the softening and "bridging" together that causes stoppages in the heater's moving bed.

In Gas Synthesis Generators

ALUNDUM fired shapes, backed up with ALUNDUM insulating castable, provide ideal linings for generators of this type because of their high-purity, high refractoriness, chemical stability, and inertness to reaction with contacting atmospheres.

Many Other Uses

for Norton high-purity fused alumina materials include: pure oxides and sintered refractories, refractory cements, wear-resistant parts, laboratory ware, etc.

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For more data on advertised products, use Readers' Service Cards, last page.

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New Equipment . . .

adopted ductile (nodular) iron for use in vessels at pressures to 1000 psi and temperatures to 650 F (80 percent of cast steel service).

The inverted bucket design of these traps incorporates a dual-fulcrum action of the valve lever which provides high discharge flow when required, yet permits efficient handling of very low condensate loads. All internal parts are made of heavy stainless steel to withstand the most severe operating conditions. The bucket is deep-drawn with no seams or joints. Wear is at a minimum since only the bucket and lever move. Replaceable Anum-Metl valve and seat are guaranteed leakproof for one year.

The Strong 540 Series Traps are available in five standard sizes with pipe connections from one-half inch to two inches (screwed or socket weld), and discharge capacities to 42,800 pounds of water per hour. Strong, Carlisle & Hammond.

Circle E20 green card, last page

Wider Speed Changes With New S-Section Sheave

A new compact "S" section "Vari-Pitch" sheave which permits wider speed changes and increased horsepower transmitting capacity has just been announced.

The new single-groove "S" section sheave has a range of 5.5 inches minimum to 120 inches maximum. It complements the present wide range "Q" and "R" section "Vari-Pitch" and companion sheave line.

Companion sheaves with "Magic-Grip" bushings in sizes from 8.0 to 24.0 inch pitch diameter are available along with "S" section belts in lengths from 54 to 150 inches. The "S" section belt has a maximum width of two and one-sixteenth inches which is wider than "Q" or "R" section units.

The new "S" section sheave requires no more mounting space than is needed for the smaller "R" section one groove sheave. Allis-Chalmers Manufacturing Co.

Circle E21 green card, last page

Selection of Metal Gaskets Described

A bulletin just issued describes Guardian spiral wound metal gaskets. The bulletin details the outstanding features and design factors of the metal gaskets as well as the types available for specific applications.

The gaskets consist of spiral wound strips of "V" shaped preformed stainless or cold rolled steel alternated with layers of asbestos or Teflon. They are recommended for use against steam, oils, gases and liquids including most chemicals in high pressure, high temperature applications.

Sizes of the round, oval, square, flat side, diamond and pear shaped gaskets are listed in the Bulletin. Charts for suggested sizes in relation to pressures sealed are also included.

Circle E22 green card, last page

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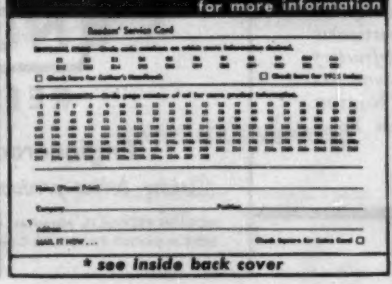

*** see inside back cover**

Flowmeter Measures With Magnet and Turbine

A new bulletin describes the performance characteristics and advantages of using the turbine-type flowmeter called the Pottermeter.

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Supporting legs on spheroid tanks fireproofed by "wet gun" method at Sinclair's Wood River Refinery.

NEW "WET GUN" APPLICATION DOES AWAY WITH OLD-TIME MESS

This is another case history where leading refineries and petrochemical plants are turning to the revolutionary new wet gun application of Blo-crete to achieve *maximum* fireproofing, without the drawbacks of old-time mess. Underwriters' Laboratories tests definitely prove that Blo-crete's combination of materials for fireproofing structural steel supports now provides up to 4-hr. fire rating protection.

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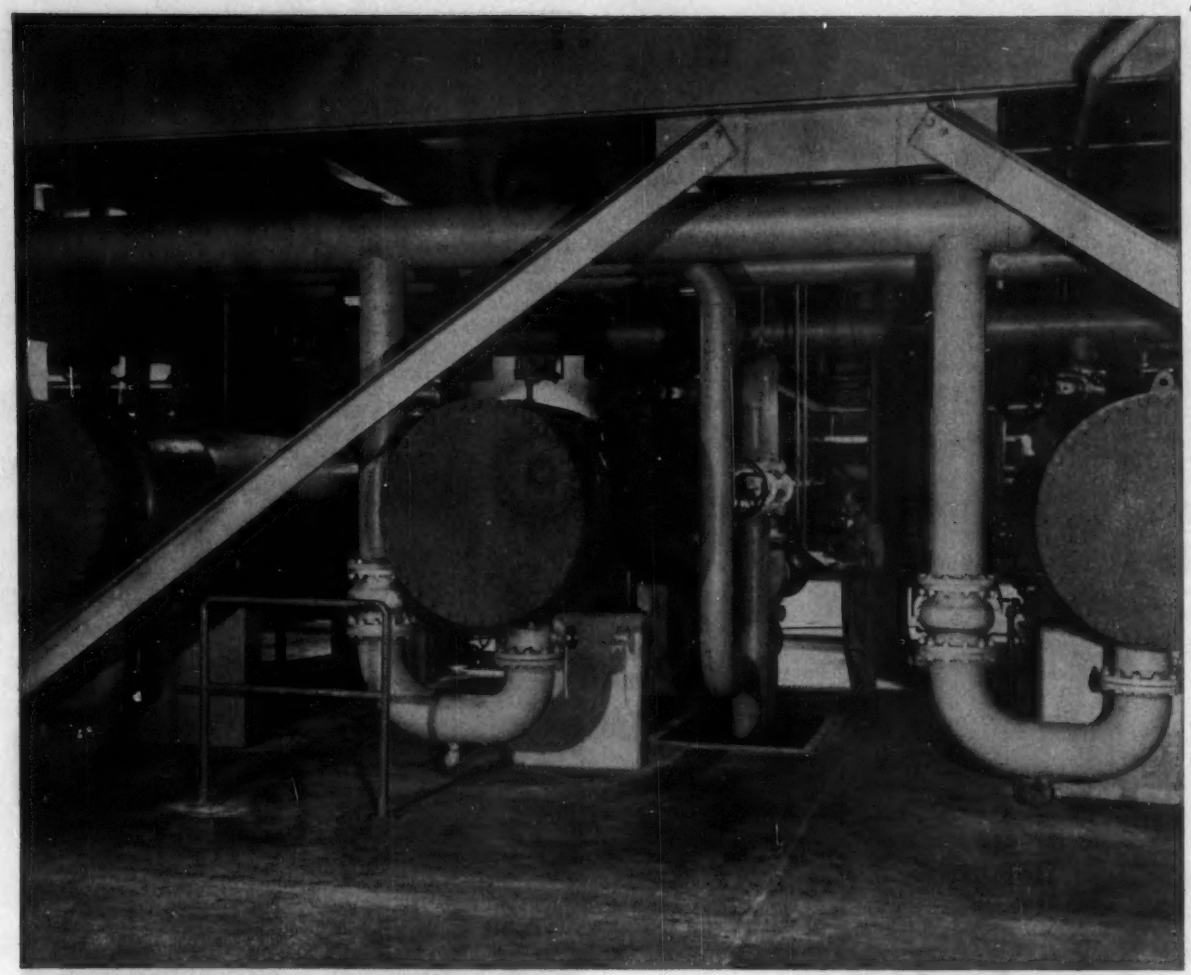

Cooling system at new Delaware refinery...

Tidewater safeguards heat exchanger tubing against salt water corrosion and erosion... uses cupro-nickel

These heat exchangers at Tidewater Oil Company's new Delaware Refinery take their cooling water from the Delaware River – in gulps of 275,000 gpm. And depending on tidal conditions, the river water at the plant intake varies from brackish to *pure sea water.*

Nearly all processes at the Delaware Refinery are continuous. A breakdown in the cooling system might force the entire plant to close. So Tidewater takes no chances. They ordered heat exchanger tubing of 70/30 cupro-nickel, over one hundred thousand pounds of it.

Cupro-nickel proven by experience

Tidewater chose cupro-nickel tubes on the strength of experience gained at the Bayonne and Avon refineries using salty bay water. Resistance to general and local corrosion ... resistance to impingement attack at tube ends due to velocity ... both prompted the use of cupro-nickel.

If you're having trouble with corrosion of heat exchanger tubes, it will pay you to examine the cupro-nickel record in detail, and check into other nickel-containing materials. You'll find the high points in a 28-page illustrated booklet "Alloys for Heat Exchanger Problems." For your copy, just write Inco.

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new idea in flow measurement. It utilizes the hydraulic pressure of the measured fluid to suspend the turbine-type rotor in an axial "floating" position. Thrust friction is eliminated, and the rotor spins freely without slippage at a rate which is directly proportional to the velocity of flow through the line being measured. Mounted within the body of the meter's rotor is a small, permanent magnet, polarized at right angles to the axis of rotation. As the rotor spins, the magnet sets up an alternating current in a coil of wire held within its field in an external mounting.

The total number of pulses generated by a sensing element is directly proportional to the total quantity of liquid that passes through the unit.

Used in conjunction with an electronic totalizer or flow rate indicator, the meter measures flow with extreme precision. The Pottermeter Co.

Circle E23 green card, last page

Pipe Insulation With Built-In Tie Wires

Development of No. 101 pipe insulation, a new speed-fastening, high-temperature pipe covering has been announced. Built-in tie wires eliminate the need for conventional tie wires so that the insulation can be applied to large diameter lines as rapidly as more costly molded pipe coverings.

Specially felted from high-temperature, moisture-resistant spun mineral wool, pipe insulation will withstand temperatures to 1200 F. Its exterior surface is faced with a metal fabric of 16 gage wires welded in

a two by two and five-eighths inch rectangular mesh and held in place by 16-gage wires tied through the spun wool to an inner facing of one-inch expanded metal lath. Speed fastening on the pipe is accomplished, as shown in the photograph, by hooking seven wires which extend from one end of the outer mesh fabric under the opposite stay wire and bending them over and back.

No. 101 pipe insulation is especially well suited for covering nested pipes and steam traced lines (see photo) since it can be manufactured to fit exactly with no waste material. Having a low alkalinity factor it will not corrode pipes in the presence of heat and moisture. It is available in two-feet sections and one and one-half-to four-inch thicknesses for pipe sizes from four to 30 inches.

The new speed-fastening material is specifically designed for runs of pipe that are to be weatherproofed with sheet metal or roofing felt. Baldwin-Hill Co.

Circle E24 green card, last page

New Equipment . . .

Fabricated Flow Nozzles Made Lighter and Cheaper

A new fabricated flow nozzle that is lighter, less expensive, easier to handle and is non-corrosive was recently announced.

The nozzle, which is about one-fifth the weight of forged steel, can be delivered in less than half the time required for forged steel. It is made to the ASME fluid flow measurement code.

Although manufacturing costs studies have not yet been completed, experience so far has indicated that the cost of fabricated nozzles will be considerably less than that of the steel units, with costs decreasing in proportion to the size of the nozzle above ten inches. The studies also indicate that cost of fabricated nozzles below eight inches will be about the same as that of steel nozzles.

The company so far has manufactured the new nozzles up to 24 inches and has made quotations on 30-inch units. Penn Instrument Division of Burgess-Manning Co.

Circle E25 green card, last page

For More Information On New Equipment Use the Readers Service Card

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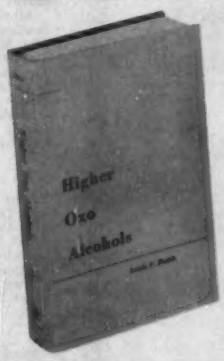

By LEWIS F. HATCH, Technical Consultant, Enjay Laboratories. This book offers the first complete review of the oxo reaction. It provides a thorough review of the extensive patent literature on the subject—covering all phases from production through application—and stresses the practical industrial implications of the subject as well as its theoretical aspects. In addition, the author presents valuable new material about the most important derivatives of the process—the higher oxo alcohols.

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First Class Permit No. 7 (Sec. 34.9, P. L. & R.), Houston, Texas

Petroleum **Refiner**

BOX 2608

HOUSTON 1, TEXAS U.S.A.

Circle code number for more data on "New Equipment" editorial items

Circle page number for more information on ADVERTISED products

PETROLEUM REFINER Readers' Service Card — **February, 1958, Issue***

EDITORIAL ITEMS—Circle code numbers on which more information desired:

E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13
E14	E15	E16	E17	E18	E19	E20	E21	E22	E23	E24	E25	

ADVERTISEMENTS—Circle page number of ad for more products information:

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26	27	28	29	30	31	32	33	34	34A	34Ba	34Bb	34C	34Da	34Db	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
80	81	82	83	84	85	86	87	88	89	90	93	94	96	100	101	102	171	173	175
176	177	178	179	180	181	183	185	186	187	188	189	190	191	192	193	194	195	196a	196b
197	198	203	205	206	207	209	210	212	213	214	215	216	217	218	219	221	222	223	224
225	226	227	228	229	230	231	232	233	234	235	236	237	238	239a	239b	240	241	242	243
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285b	285c	286a	286b	287	288a	288b	288c	288d	288e	289a	289b	290a	290b	290c	290d	291a	291b		

Name (Please Print)_____

Company_____ Position_____

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2. For more data on Advertised Products and Services, circle on card the actual page number of the advertisement as listed in the Advertisers' Index on the preceding page.
3. Then, print your name, title, company and complete mailing address and drop the card in the mail. PETROLEUM REFINER's Readers' Service Department will promptly forward your requests to the company concerned. The requested information will then be mailed directly to you.

PETROLEUM REFINER Readers' Service Card — **February, 1958, Issue***

EDITORIAL ITEMS—Circle code numbers on which more information desired:

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Postage Will be Paid by Gulf Publishing Company

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Petroleum **Refiner**

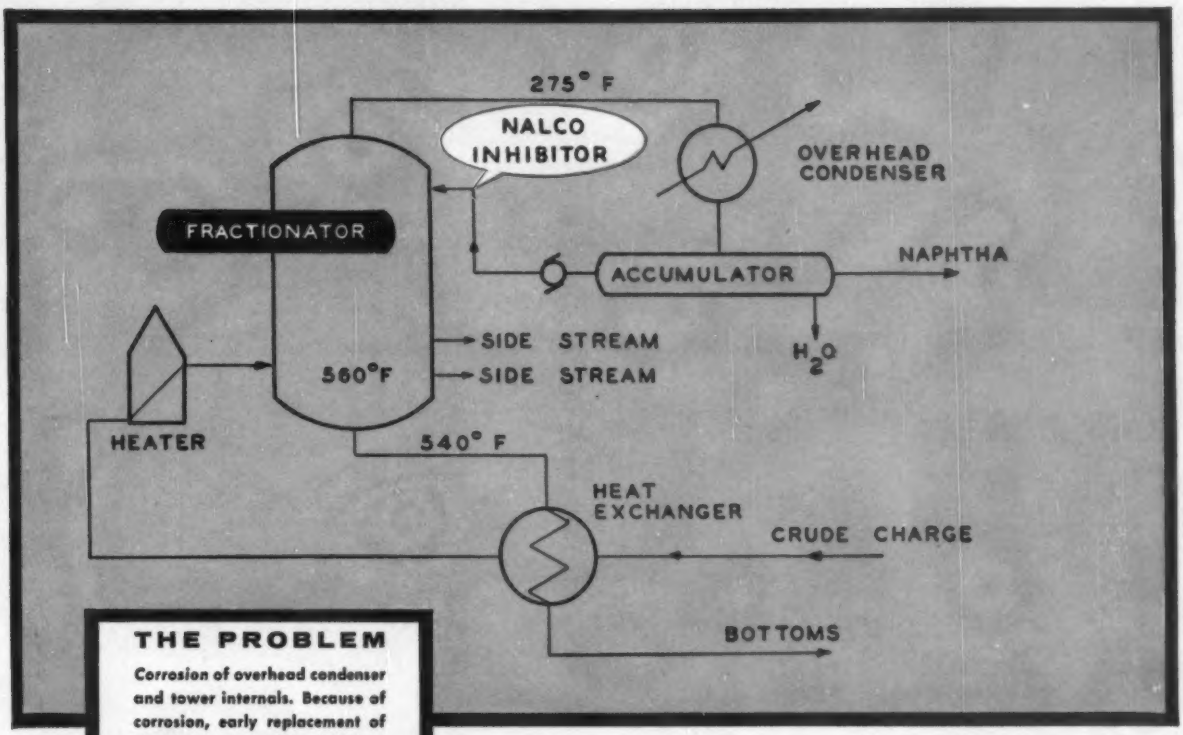
BOX 2608

HOUSTON 1, TEXAS U.S.A.

Quick-Easy

Use these cards to help keep informed on what's new . . . for more job-help information on equipment and services.

HOW *Nalco* INHIBITORS CUT DOWNTIME 74% ...AND SAVED THIS FRACTIONATING TOWER



THE PROBLEM

Corrosion of overhead condenser and tower internals. Because of corrosion, early replacement of the tower was contemplated.

THE TREATMENT

Nalco Corrosion and Fouling Inhibitor applied into overhead reflux.

THE RESULT

In this case only one point of application protected both fractionator and overhead equipment. Iron in accumulator water brought below 0.5 ppm as compared to previous 100-150 ppm. Corrosion and plugging stopped, tower saved, and downtime for cleaning reduced by 74%.

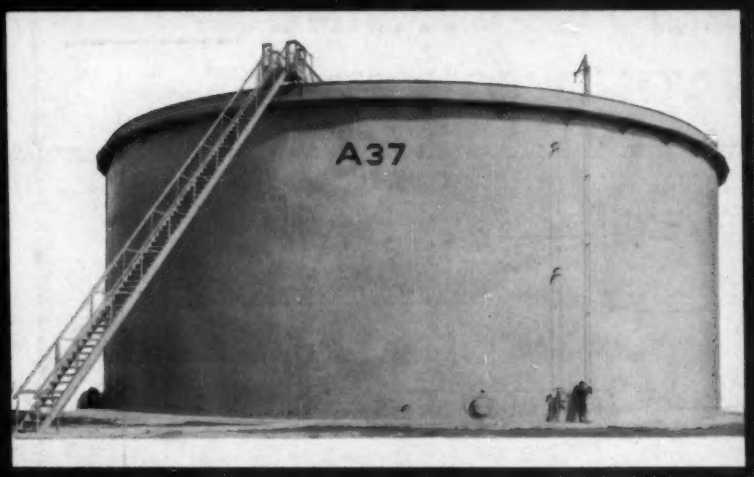
EFFECTIVE Nalco corrosion control is very low-cost protection. For example, this refinery not only avoided the cost of a new tower, but cleaner tower internals actually resulted in better fractionation and higher quality products. If you would like further facts on Nalco Corrosion and Fouling Inhibitors, ask your Nalco Representative or write direct.

NATIONAL ALUMINATE CORPORATION
6259 West 66th Place • Chicago 38, Illinois
Telephone: PArtsmouth 7-7240
CANADA: Alchem Limited, Burlington, Ontario
NORTHWESTERN UNITED STATES, HAWAII and ALASKA
The Flox Company, Inc., Minneapolis 3, Minnesota
ITALY: Nalco Italiana, S.p.A.
WEST GERMANY: Deutsche Nalco-Chemie GmbH
SPAIN: Nalco Espanola, S.A.

THE *Nalco*® SYSTEM ... SERVING INDUSTRY THROUGH PRACTICAL APPLIED SCIENCE

NOOTER

FLOATING ROOF TANKS



We Offer You

MAXIMUM

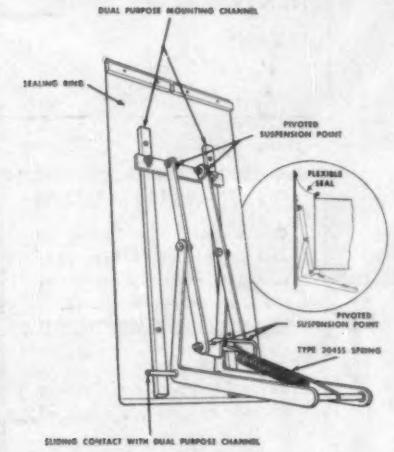
SEAL PROTECTION

MINIMUM

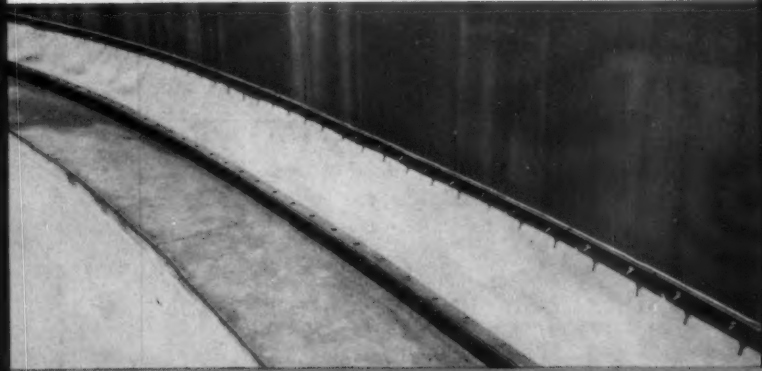
MAINTENANCE

NOOTER is fully experienced in the fabrication and erection of double deck, pontoon and pan type floating roofs—all with the patented Nooter Seal. The Nooter design means better protection for your product because of the more efficient seal . . . minimum maintenance because there is no direct contact with the sealing ring, therefore minimum wear . . . and minimum delay in construction because easier installation and alignment are made possible by the new seal design. These advantages mean a better floating roof tank at a lower cost.

This Patented NOOTER SEAL HANGER is One Reason Why!



This exclusive Nooter 2-Point suspension seal hanger has one pivoted and one sliding point of contact with the dual-purpose mounting channel. This channel serves (1) as a means of attaching seal hanger to shoe without direct contact of seal hanger to shoe, and (2) as a method of providing even distribution of the forces of seal hanger over entire height of shoe.



you can also update your old tanks with the new NOOTER SEAL

The Nooter Seal is readily adaptable to any existing welded or riveted tank. Requires minimum modifications for fast, easy instaliation.

For your next floating roof tank, or seal replacement, send your inquiries to Nooter. You'll find Nooter quality and dependable deliveries your best equipment investment.

Catalog 158 on Nooter Floating Roof Tanks is yours for the asking.

NOOTER CORPORATION

"Since 1896"

Steel and Alloy Plate Fabricators and Erectors..."Boilermakers"

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